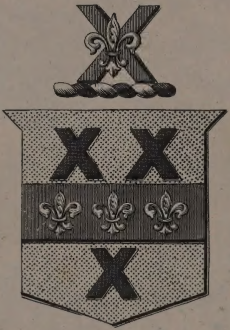

E. BARCLAY-SMITH, M.D.

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DESCRIPTIVE

A N A T O M Y.

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DESCRIPTIVE ANATOMY.

ANGEIOLOGY.

Definition and objects of Angeiology.

Angeiology (ἀγγεῖον, a vessel) is that division of anatomy which treats of the organs of the circulation.

The circulating system consists of a central organ, the *heart*, the agent for propelling the blood; of the *arteries*, vessels through which the blood is conveyed from the heart to all parts of the body; of the *veins*, through which the blood is returned from all parts of the body to the heart again; and lastly of the *lymphatic vessels*, appendages of the venous system, into which their contents are ultimately poured.

THE HEART.

General description.—External and internal conformation.—Structure.—Developement.—Functions.—The pericardium.

Dissection. In order to study the external conformation of the heart, inject the cavities of the right side of that organ by the pulmonary artery, or by one of the venæ cavæ, taking care to tie the other; the cavities of the left side may be filled from the aorta, or one of the pulmonary veins.

Tallow, wax, and glue-size are the most suitable materials for this purpose.

The *heart* (καρδία), the central part of the circulating apparatus, is a hollow muscular organ divided into several compartments, and intended for propelling through the arteries into all parts of the body, the blood which is poured into it from the veins.

The heart is one of the most important organs in the body. In a zoological point of view, the presence or absence of a heart, and the complexity or simplicity of its structure deserve particular attention, because such variations in regard to the central organ of the circulation are accompanied by very great modifications in the entire organism.*

Congenital absence of the heart is extremely rare, and is always accompanied with other malformations, more especially with absence of the brain. These deficiencies are incompatible with life.

Number. Man and vertebrated animals have only one heart; in mollusca

* Vertebrata and mollusca are the only animals which are provided with a heart. Mammalia and birds alone possess a double heart, *i. e.* a heart with two auricles, and two ventricles. Fishes and reptiles have a simple heart, *i. e.* a heart with only one auricle and one ventricle, this ventricle being pulmonary in fishes, and both systemic and pulmonary in reptiles.†

† [A central pulsating vessel is found in some of the higher radiata, and in the articulata; in some of the latter it constitutes a strong muscular ventricle, but the addition of a systemic auricle to this ventricle is first observed in the mollusca; in the invertebrata generally the ventricle is entirely systemic: in the higher cephalopods there are two branchial hearts. In fishes the heart consists of a systemic auricle, and a pulmonary ventricle, and is preceded by a sinus venosus, and followed by a bulbus arteriosus. In the early condition of the batrachia the same conformation exists; but in their adult state, and also in all reptilia, there are *two* auricles and one ventricle, the additional auricle being pulmonary, *i. e.* receiving the blood from the lungs. In the higher reptilia the single ventricle, which is both systemic and pulmonary, is divided by an imperfect septum ascending from the apex of the heart. In the crocodilus lucius, as well as in birds and mammalia, this interventricular septum is complete, so that in them the heart is divided into two auricles and two ventricles, the cavities of one side being systemic, and of the other pulmonary.]

it is double, or even triple. This plurality of hearts, instead of being an index of perfection, should be regarded as a subdivision, and less perfect condition of the organ. We shall see that man, as well as mammalia and birds, has in reality two hearts united into one.

Situation. The heart is situated at the junction of the upper third with the lower two thirds of the body; hence the upper parts of the system are more immediately under the influence of this important organ.*

The heart (*l*, *fig.* 170.; *o*, *fig.* 171.) occupies the middle of the thoracic cavity; it is situated in the mediastinum, in front of the vertebral column, behind the sternum, which forms a kind of shield for it, and beyond which it projects on the left side; it is placed between the lungs, and above the diaphragm, by which it is separated from the abdominal viscera.

It is retained in this situation by the pericardium (*p p*, *fig.* 170.), a fibro-serous covering, which is itself closely adherent to the diaphragm (*x*); by the pleuræ (*q q*), which are reflected on each side of it, to form the parietes of the mediastinum; and lastly, by the great vessels which pass out or enter at its base.

These means of attachment are not such as to prevent the heart from undergoing remarkable changes of position, depending upon peculiar attitudes, upon shocks acting on the body, or upon diseases of the surrounding organs. Thus in a case of hydrothorax on the left side, the apex of the heart struck against the right side, and gave rise to the suspicion that the viscera were transposed.

Size and weight. Neither the size nor the weight of the heart can be estimated with exactness, on account of the numerous individual varieties in both. It is very difficult to determine the limits in either the one or the other, between a healthy and a morbid condition; and a heart which would be considered normal in one individual, would be regarded as hypertrophied in another.

The defects of the method proposed by Laennec, for obtaining an approximative estimate of the size of the heart, by comparing it with that of the closed hand of the same subject, afford sufficient evidence of the difficulty of arriving at an accurate result in this matter. †

No organ in the body is more subject to enlargement than the heart; when caused by dilatation of the cavities it constitutes *aneurism* of the heart (*dilatation*); when due to thickening of the parietes, it is termed *hypertrophy*. When enlargement occurs from both these causes, the heart acquires an enormous size, and has been called *bullock's heart* (*hypertrophy with dilatation*).

The size of the heart may be estimated directly by ascertaining the quantity of water displaced by it, and by admeasurement; it may also be determined in an approximate manner by its weight, which bears a certain relation to the size.

In making these estimates it is necessary to distinguish the size and weight dependent upon thickness of the parietes of the heart, from the increase occasioned by blood contained in its cavities. In order to obtain comparative results upon this point, the heart must be weighed and measured both in its empty and its distended state. The average weight of the empty heart is from seven to eight ounces. Some atrophied hearts do not weigh more than two ounces: dilated and hypertrophied hearts, when empty, may weigh twenty-two ounces. The ordinary weight of the heart distended with tallow is twenty-four ounces. I have seen dilated hearts also filled with tallow, which weighed three pounds.

As to the admeasurement, we shall apply it in succession to the ventricles and to the auricles.

Form, direction, and divisions. The heart has the form of a flattened cone, the axis of which is directed obliquely from above downwards, from the right

* The distance from the heart to the brain varies in different individuals, according to the length of the thorax and the neck. This difference may amount to two inches, and may exercise some influence upon the cerebral circulation. In consequence of this observation, extreme shortness of the neck has been regarded as a predisposing cause of apoplexy.

† The large hand of a workman does not imply the existence of a larger heart, than the small hand of a female, or of a man exempt from manual labour.

to the left side, and from behind forwards. This direction, which is peculiar to the human species (for in the lower animals the heart is vertical), appears to have some relation to the erect position. The heart is not symmetrical in reference to the median line of the body, nor yet in regard to its own axis.

The heart is divided into *ventricles* and *auricles*. The ventricles (*l o*, *figs.* 191, 192.) constitute the chief part, in some measure the body of the organ, the conical form of which is determined by them; the auricles (*m n*) are a kind of appendices, which can be well seen only when the heart is raised; they occupy the base of the organ; the limit between the auricles and the ventricles is indicated by a circular furrow.

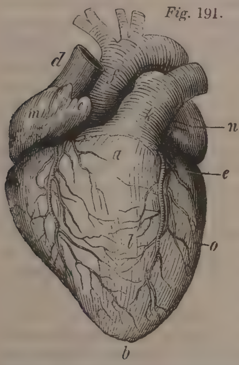
External Conformation of the Heart.

The External Surface of the Ventricles.

The external surface of the *ventricles*, or the *ventricular portion of the heart*, called also by the ancients the *arterial portion*, because the arteries arise from it, presents for our consideration an anterior and an inferior surface, a right and a left border, a base and an apex.

The *anterior* or *sternal surface* (*fig.* 191.) is convex, and is divided into two unequal parts, a larger on the right, and a smaller on the left side, by the *anterior furrow of the heart* (*e b*), which passes vertically from the base towards the apex, is occupied by the anterior coronary artery, and is often obscured by fat. All that part of the organ which is to the right of the furrow belongs to the right ventricle (*l*), all on the left belongs to the left ventricle (*o*). The furrow itself corresponds to the septum between the ventricles.

Fig. 191.



This surface, or rather the pericardium which covers it, is in relation with the sternum, more especially in that part which lies to the right of the furrow; also with the costal cartilages of the left side, and with the lungs, which cover it more or less completely. It should be remarked that, in large hearts, this surface, or its pericardium, corresponds immediately to the sternum, while in the natural state it is situated at some distance from that bone. The relations of the heart with the anterior wall of the thorax enable us to examine its condition by means of percussion and auscultation.

The *inferior* or *diaphragmatic surface* (*fig.* 192.) is plane and horizontal; it rests upon the diaphragm, which forms a sort of floor for it, and separates it from the liver and the stomach. Like the anterior surface it is marked by a longitudinal furrow, the *posterior furrow of the heart* (*e b*), which is traversed by vessels, and concealed by fat. It differs from the anterior furrow in running parallel to the axis of the heart, and dividing its diaphragmatic surface into two nearly equal parts, excepting near the apex. In consequence of the relations of this surface, pulsations are observed in the epigastrium, which are sometimes much more distinct than those felt upon the anterior wall of the thorax. Another result of these relations is, that the same meaning is attached to the terms *scrobiculus cordis* and *pit of the stomach*, and also to the expressions *pain at the heart*, *pain at the stomach*, *&c.*

The *right* or *lower border* is thin and horizontal, and rests upon the diaphragm; it is straight near the apex, but becomes convex towards the base. The *left border* (*o b*, *fig.* 191.) is very thick, convex, and almost vertical; it resembles a surface rather than a border, and corresponds to the left lung, which is deeply notched to receive it.

The *base* of the ventricular portion of the heart is turned upwards, backwards, and to the right side. From it arises, upon an anterior plane, an artery, which immediately passes from the right to the left; this is the pulmonary artery (*k*): the portion of the ventricle from which it proceeds forms a prominence on the right side of the anterior furrow of the heart, and is prolonged towards the left, becoming narrower at the same time, so as to form a funnel-shaped projection (*infundibulum, conus arteriosus*) (*a*), extending a little beyond the base of the ventricles. Upon a second plane we find the aorta (*f*), the origin of which, from the left ventricle, is concealed by the funnel-shaped prolongation of which we have just spoken. On a third plane we find a circular furrow (*o u, fig.* 195.), separating the auricles from the ventricles. Its posterior half is occupied by the coronary arteries and veins, and the anterior and posterior furrows of the heart terminate in it at right angles.

This circular furrow at first sight appears to be superficial, but is very deep in its posterior half. If we dissect carefully down to the bottom of this furrow, it is found that the base of each ventricle is, as it were, turned inwards, so as to be in contact by a broad surface with the base of the auricle. We find, also, that the base of the ventricles is cut obliquely, and hence the anterior surface of the heart is longer than the posterior surface. The difference in length between these two surfaces is about fifteen lines upon the right, and from nine to ten lines upon the left ventricle. Thus, in a heart of the ordinary size, the length of the ventricles in front was three inches three lines, and behind two inches three lines. In a very large heart the length in front was four inches, and behind only three. The circumference of the base of an injected heart, of the average size, measured ten inches; that of a large heart was thirteen inches six lines.

The *apex* (*b*) or *point* of the heart is slightly curved backwards in the majority of subjects, and is notched opposite the junction of the two longitudinal furrows. This notch, which is partially concealed by vessels and adipose tissue, divides the apex of the heart into two unequal portions; a right and smaller, belonging to the right ventricle, and a left and larger portion, belonging to the left ventricle. The relative size of the two portions of the apex of the heart is not constant. In some cases of hypertrophy of the left ventricle, the apex of the heart is entirely formed by it; in other cases, on the contrary, the apex of the heart is nearly equally subdivided.

The apex of the heart is directed forwards, downwards, and to the left, and corresponds to the cartilages of the fifth and sixth ribs of the left side, and therefore to the region of the corresponding mamma; the left lung is notched opposite the apex of the heart, so that the latter strikes directly against the parietes of the thorax.

The External Surface of the Auricles.

The *auricles* (*m n, figs.* 191, 192.), forming the *auricular portion of the heart*, are saccular cavities in which the veins terminate; they may, in fact, be regarded as dilatations of those vessels, and hence this portion of the heart is called the *venous portion*, in contradistinction to the ventricles. They are situated upon the hindermost portion of the base of the heart (*fig.* 192.).

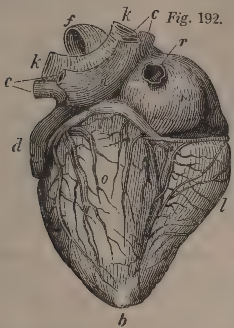
Their *size* varies in different individuals; in an injected heart, the average height of the auricular portion is two inches; its antero-posterior diameter is nearly the same; and when the auricles are distended, its transverse diameter extends beyond the ventricles on each side.

The *shape* of the auricular portion of the heart, which can only be accurately determined by means of injection, is irregularly cuboid. It therefore presents several surfaces; its *anterior surface* is situated on a plane much further back than that of the front of the ventricles (*fig.* 191.). It is concave, and describes three fourths of a circle, so as to embrace the aorta and the pulmonary artery, being moulded upon those vessels, and completely concealed by them. The

anterior surface of the auricular portion has no anterior furrow along the middle line.

The *posterior surface* (*fig.* 192.) is convex, and is continuous with the inferior surface of the ventricles; it presents a vertical furrow, which is prolonged upwards from the posterior furrow of the ventricles, then deviates to the left side, and forms a curve, the concavity of which is directed towards the right; it corresponds to the septum of the auricles. Immediately to the right of this furrow, we find the termination of the vena cava inferior (*r*), and lower down, that of the great coronary vein. The posterior surface of the auricles is turned towards the vertebral column, from which it is separated by the œsophagus and the aorta.

Fig. 192.



The *superior surface* of the auricular portion forms the highest part of the heart, and is directed backwards and towards the right side. It is divided by a furrow, which is convex on the right side, is continuous with the furrow upon the posterior surface, and, like it, corresponds to the inter-auricular septum. Upon this surface we find the terminations of five different veins: one only of these is to the right of the furrow, viz. that of the vena cava superior (*d*, *fig.* 191.); the other four are on the left of the furrow, and are those of the four pulmonary veins, which are arranged in pairs (*c c*, *fig.* 192.), two at the extreme left of the auricles belonging to the left pulmonary veins, and two immediately in the neighbourhood of the posterior furrow belonging to the right pulmonary veins. This surface corresponds to the bifurcation of the trachea, which, as it were, rides upon it.

The *extremities* of the auricles, or the *auriculæ*, are free, and somewhat resemble the pendulous portion of a dog's ear; hence the term *auricles*. They are indented like a cock's comb; the right auricula is anterior, the left posterior.

The right auricula (*c*, *fig.* 191.) is broader and shorter than the left; it is triangular and concave, so as to embrace the aorta, in front of which it projects; the left auricula (*i*) is narrower and longer, it is sinuous, and curved twice upon itself like an italic *S*; it embraces the pulmonary artery, and terminates opposite the highest part of the anterior furrow of the ventricles.

The right auricula is continuous with the rest of the corresponding auricle, without any well marked line of separation; but the left auricula is very distinct from its auricle; and upon this latter side, the distinction pointed out by Boerhaave, between the sinuses and the auricles properly so called, may be particularly observed: according to him, the sinus constitutes the body of the auricle, and may be regarded as a dilatation of the veins, whilst the auricular appendix forms the proper auricle.

The Internal Conformation of the Heart.

The heart is divided internally into four cavities, which are separated from each other by complete or incomplete septa; two of these cavities belong to the auricles, and two to the ventricles. There are a right ventricle and auricle, and a left ventricle and auricle. The auricle and ventricle of the same side are separated by incomplete septa or valves, and communicate with each other. The cavities of the opposite sides are separated by complete septa, and do not communicate. The heart is therefore, in this latter respect, truly double. The right ventricle and auricle constitute the right heart, also named the *cœur à sang noir*, from the colour of the blood which it contains; and the *pulmonary heart*, because it propels the blood into the lungs. The left ventricle and auricle constitute the left heart, called also the *cœur à sang rouge*, or the *aortic heart*, because it throws the blood into the aorta.

The Internal Conformation of the Ventricles.

Dissection. In order to obtain a general idea of the internal conformation of the heart, make a series of sections at right angles to its length, or else make an incision along its borders parallel to its long axis.

To obtain a more exact notion of the ventricles make a V-shaped incision in the right ventricle, letting one branch of the incision extend along the anterior furrow, and the other along the right border, while the angle at which they meet should correspond to the apex of the ventricle.

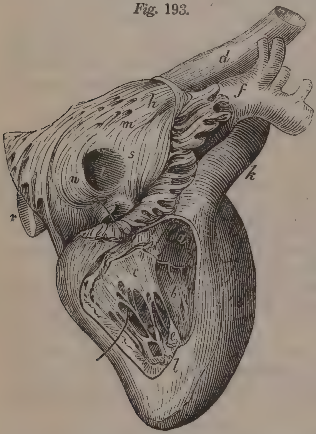
The best method of opening the left ventricle consists in making a vertical section through the septum; but in doing this the right ventricle must be sacrificed.

In order to obtain a general view of the appearance of these cavities, they may be prepared in the dried state. For this purpose, the heart is to be injected with tallow, and then, after being dried sufficiently, to be opened in the manner above described, and immersed in warm turpentine, which will dissolve the tallow, and leave the ventricles dilated.

Interior of the Right Ventricle.

The *right ventricle* occupies the right anterior and inferior portion of the heart, and has, therefore, been called the anterior or the inferior *ventricle.* Its cavity (*fig.* 193.) has a three-sided pyramidal form. Its inner wall (*b*) is convex, and is formed by the septum of the ventricles; in its lower half it has a well marked reticulated appearance, which is almost entirely absent in the upper half (*a*). The anterior and inferior walls (partly removed in *fig.* 193.) are both concave, and are remarkable for their thinness, so that they are always collapsed when the ventricle is empty. The base of this ventricle presents two openings, which are separated from each other by a projecting part, and which may be compared to the wide circular end, and the narrow mouthpiece of a huntsman's horn. The opening into the auricle (in which a bristle is placed) corresponds to the wide end of the horn, and the infundibulum (*a*) to the narrower end. The transverse diameter of the *base* of this ventricle is nearly equal to its height. The summit (*l*) is turned towards the apex of the heart.

Fig. 193.



The walls of the right ventricle are very remarkable for their reticulated or areolar character; this areolar portion might be termed the *corpus cavernosum of the heart,* for it presents the spongy structure of the erectile tissues. The fleshy columns which form the areolæ are observed not only upon each of the walls of the ventricle, but they also pass across the cavity of the ventricle near its summit, extending from one wall to the other; in consequence of which the capacity of the ventricle is singularly diminished.

The cylindrical fleshy columns (*columnæ carneæ, teretes lacerti*), which separate the meshes or areolæ, are of three kinds. Some (*e*) are attached to the parietes of the heart by one of their extremities and are free in the rest of their extent; they terminate by a kind of simple or double mamillated projection, from which proceed small *tendinous cords* (*chordæ tendineæ*), that are inserted into the auriculo-ventricular valves (*c*). They are very few in

number, and have been named the *muscles of the heart* (*musculi papillares*). The fleshy columns of the second kind are free throughout the whole of their extent, excepting at their extremities, which are attached to the walls of the ventricle. These columns, which are the most numerous, are divided and subdivided to form the areolæ. The third kind of columnæ carneæ adhere to the walls of the ventricle by one of their sides; they are therefore sculptured like pilasters upon the walls of the ventricle.

Most of the columnæ carneæ pass from the apex towards the base of the heart. In all their free portion, the columns of the two first kinds are attached to each other or to the walls of the ventricle, by means of small *tendinous cords*, which are much more delicate than those proceeding to the valves. The areolar muscular structure just described is the essential constituent of the walls of the ventricle, but in addition to it there is a rather thin, compact, and non-reticulated layer of superficial fibres, on which depends the smooth appearance of the external surface of the ventricle.

The orifices of the right ventricle. At the base of the right ventricle there are two orifices, one *auricular*, which establishes a communication between the ventricle and the auricle, the other *arterial*, which leads into the pulmonary artery. They are both furnished with valves.

The *right auricular* or *auriculo-ventricular orifice* (through which the bristle is inserted, *fig.* 193.) is placed at the posterior and right part of the base of the ventricle; it is elliptical, and is provided with a membranous structure, called the *tricuspid* or *triglochin valve* (*c*), which projects into the interior of the ventricle. This valve is of an annular form (*annulus valvulosus*). Its *ventricular surface* (*t t t*, *fig.* 194.) is directed towards the parietes of the ventricle, and receives a great number of small tendinous cords, which being attached to it at different points, give it an irregular aspect. Its *auricular surface* (*t t t*, *fig.* 195.), which is turned towards the axis of the ventricle, is smooth. The *adherent border* is fixed to the margin of the auricular orifice. The free border or margin forms a ring, the diameter of which is equal to that of the adherent border: this margin is irregularly divided. so that, instead of the three segments (*t t t*) generally described, and from which the name of the valve has been derived (τρεῖς, *tres*, three, and γλωχὶς, *cuspis*, a point), some authors admit four or even six segments.

Fig. 194.

Fig. 195.

The construction of the tricuspid valve can be understood only by regarding it as composed of two parts, an anterior, corresponding to the anterior half of the elliptical auriculo-ventricular orifice, and a posterior, corresponding to the posterior half of the same. The tricuspid valve is not unfrequently interrupted on the left side opposite the junction of these two valves. This valve might with as much propriety be termed *mitral*, as that which is attached to the left auriculo-ventricular opening.

To the free margin of the valve, upon which some small nodules are occasionally found, are attached a number of tendinous cords of a nacreous aspect, which are extremely strong considering their tenuity. These small cords, or rather tendinous filaments, always arise in greater or less number from the summits of the columnæ carneæ; diverging from thence, often bifurcating during their course, and sometimes becoming united together, they terminate, some at the free margin, others at the ventricular surface of the valve, and others again at its adherent border.

All the small tendinous cords do not arise from the columnæ carneæ of the

first kind; many of them proceed directly from the parietes of the heart. We constantly find a fasciculus of diverging cords arising from the septum.

These cords are so arranged, that by drawing upon them, the valve is depressed and stretched. We find, in fact, that both in the anterior and posterior part of the tricuspid valve, those cords which arise from the free margin on one side converge towards those of the opposite side, some even crossing each other in the form of the letter X.

The *arterial* or *pulmonary orifice* (*ostium arteriosum*, *d*, *fig.* 194.) is placed at the anterior part of the left side of the base of the right ventricle. It is separated from the auricular orifice by a tolerably prominent muscular band which is concave on its lower surface, and divides the right ventricle into two portions, an auricular and a pulmonary portion or infundibulum. This orifice is circular and is provided with three very distinct valves, which are named *sigmoid* or *semilunar* (*f*, *fig.* 195.; *a a a*, *fig.* 196.).* Although thin and semi-transparent, they are very strong. They are directed vertically as the blood is passing from the ventricle into the artery, and become horizontal when it tends to flow back from the artery into the ventricle. Of their two surfaces, the ventricular corresponds to the cavity of the ventricle; the other, or arterial surface, includes between it and the walls of the artery, a small cul-de-sac, which has been compared to a pigeon's nest. The adherent border of each valve is convex, and directed towards the ventricle; its free margin presents in the middle a small nodule, by which it is divided into two semilunar halves.

Fig. 196.

When depressed the valves completely close the vessel, the three nodules filling up the triangular interval left between the approximated free margins. These valves must therefore oppose the reflux of the blood into the ventricle; but the resistance offered by them is easily overcome by an injection thrown into the pulmonary artery.

Interior of the Left Ventricle.

The left ventricle occupies the left upper and back part of the heart; it is evidently constructed upon the same fundamental type as the right ventricle, but differs from it in many respects, as we shall now proceed to show.

Difference in situation. The different positions of the two ventricles are sufficiently known from what has already been stated; but it is important to remark, that the left ventricle projects beyond the other at the apex of the heart (*fig.* 197.), whilst the right is more prominent at the base in consequence of the existence of the infundibulum.

Difference in shape. The right ventricle is pyramidal and becomes collapsed when not distended; the left is conical and convex, not only on its free surface (*b*), but even at the septum (*a*, *fig.* 194.), where it seems to project into the interior of the right ventricle.

Difference in size. It is generally stated, in accordance with Senac, Winslow, and Haller, that the right ventricle is more capacious than the left: this statement is founded upon direct observation, which proves that the right ventricle gains more at the base than the left does at the apex; also upon deductions made by comparing the right auricle and the pulmonary artery with the left auricle and the aorta; and lastly, upon the results obtained by injecting the cavities of the heart. No two observers agree as to the exact numbers which would represent the capacities of the two ventricles, as the following different

* It is extremely rare to find any anomaly in the number of these valves, either by an increase or a diminution of them.

estimates will show. The capacity of the left ventricle to that of the right has been stated as 31 to 33, as 10 to 11, as 5 to 6, as 2 to 3, and as 1 to 2. (*Haller*, t. i. l. iv. sect. 3. p. 327.)

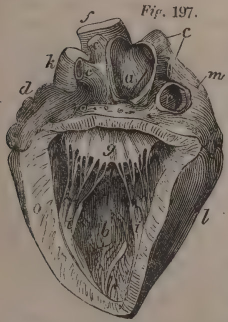
Now, the discrepancies in these estimates prove either the deficiency of the methods of observation, or the existence of real differences resulting from a greater or less amount of accidental obstruction to the pulmonary circulation occurring shortly before death. In the great majority of subjects the right ventricle is proved to be more capacious than the left, and this, according to the judicious remark of Sabatier, depends upon the state of the circulation through the heart during the last moments of life, at which time the blood flows back from the lungs into the right ventricle, whilst the left ventricle not experiencing a similar obstruction, and moreover acting with greater vigour, empties itself more or less completely of the blood contained within it. After death by decapitation the right ventricle is as much contracted as the left.

The condition of the heart, then, in the dead body, in which that organ is found as it was at the moment of death, affords us no means of judging of the relative capacity of its cavities during life. If by tying the aorta in a living animal we cause stagnation of the blood in the left ventricle, whilst the exit of that fluid from the right cavities through the pulmonary artery remains unimpeded, the relative capacity of the two ventricles will be found to be exactly the reverse of what is generally indicated.

The gradual injection of the heart with wax or tallow, so as to distend the ventricles without producing laceration, enables us to determine the size and the weight of the mass of injection contained within each cavity of the heart, and also to measure these cavities under similar conditions, that is to say, in a state of distension. From observations which I have made in this way it appeared, that the left ventricle was rather more capacious than the right.

Difference in the appearance of the cavity and in the structure of its parietes. In the left ventricle we find the three kinds of columnæ carneæ. Of the columns of the first kind there are only two (*i i*, *fig.* 197.), which are remarkable for their great size. Their summits are almost always bifurcated, and sometimes they are divided into three parts; not unfrequently each of these columnæ results from the apposition of two or three others, which are united by small fibrous cords or filaments.

Fig. 197.



The fleshy columns of the second kind are smaller in the left than in the right ventricle. The areolar arrangement is less strongly marked, and is observed only in the innermost layer, excepting always at the apex, the whole thickness of which, with the exception of the most superficial layer, presents the cavernous arrangement. Moreover, the areolæ are remarkable for their small size, and for the slenderness and number of the columnæ by which they are surrounded. These muscular areolæ are often completed by fibrous cords.

Difference in thickness. The walls of the left ventricle are much thicker than those of the right (*figs.* 193, 194. 197.). The proportion of one to two arrived at by Laennce is too slight; it is one to four, or even one to five. It is generally said that the muscular tissue of the heart is more compact on the left than on the right side.

Difference in the orifices. The left auriculo-ventricular orifice (through which a bristle is inserted, *fig.* 197.) exactly resembles the right one, and like it, is provided with a valve (*g*) analogous to the tricuspid, and named by Vesalius the *mitral valve*, from its being regularly divided into two opposite segments (*m m*, *figs.* 194, 195.). The mitral valve is stronger than the tricuspid, it is thicker and longer, and receives stronger and more numerous chordæ

tendineæ. These differences are more particularly observed in the right segment of the mitral valve which projects like an incomplete septum into the cavity of the ventricle, and appears to divide it into an aortic and an auricular portion; the left segment of the valve (*g, fig.* 196.), on the contrary, is applied against the walls of the venticle.

The aortic orifice (*e, fig.* 194.) exactly resembles the pulmonary orifice of the right ventricle; like that opening it is also provided with three sigmoid valves (*e, fig.* 195.), which differ from those of the pulmonary artery merely in being stronger, and in having larger nodules or globules upon their free borders; and as Arantius admitted their existence only in these valves, they are therefore called *globuli, noduli* or *corpora Arantii.*

The right auriculo-ventricular and arterial orifices are placed at a distance from each other, but the corresponding orifices of the left side are contiguous, so that the adherent border of the right half of the mitral valve is continuous with the adherent border of the corresponding sigmoid valve; and hence it follows, that when these valves are removed, the base of the ventricle presents only one orifice.

Interior of the Auricles.

Dissection of the right auricle. Make a horizontal incision from the auricula to the inferior vena cava, and then a vertical one from the vena cava superior perpendicularly to the first.

Of the left auricle. Make a vertical incision from before backwards, between the right and left pulmonary veins, including the entire posterior wall of the auricle. In order to have an accurate idea of the shape of the interior of the auricles, inject a heart with tallow or wax, and then examine the cast thus taken of their cavities.

Interior of the Right Auricle.

The shape of the right auricle when distended may be compared to the segment of an irregular oval, the long diameter of which is directed from before backwards. It has three walls: an *anterior*, which is convex; an *internal*, which is slightly concave, and corresponds to the septum; and a *posterior*, also concave, which forms the greatest part of the auricle, and is remarkable for the existence upon it of fleshy columns. The right auricle has four orifices in the adult, and five in the fœtus, viz. the auriculo-ventricular orifice, the opening of the vena cava superior, that of the vena cava inferior, that of the coronary vein, and in the fœtus the foramen ovale (*trou de Botal*), the situation of which is occupied in the adult by the fossa ovalis.

The *auriculo-ventricular orifice* (see *fig.* 195.), the largest of all, is of an elliptical form, from sixteen to eighteen lines in its longest diameter, which is from before backwards, and about twelve lines in its shortest diameter. It is surrounded by a whitish zone (*a q*), to which is attached the adherent border of the tricuspid valve (*t t t*). The cavity of the auricle presents a sort of constriction opposite the auriculo-ventricular orifice.

The *orifice* (*h, fig.* 193.) *of the vena cava superior* (*d*) is circular, and is directed downwards and a little backwards; it has no valves; it is bounded on the left by a projecting muscular band, which separates it from the auricle, and on the right by a less prominent band intervening between it and the vena cava inferior. The former of these two bands, which are distinctly marked upon the cast of wax, separates the fasciculated portion of the auricle from the non-fasciculated portion, which seems to be formed by an expansion of the venæ cavæ.

The orifice (*i*) *of the vena cava inferior* (*r*) opens into the auricle, near the septum, not perpendicularly upwards but horizontally, and at right angles to the original direction of the vein, which is vertical. The orifice is circular

and larger than that of the superior cava; the inferior cava sometimes forms an ampulla or dilatation before it enters the auricle; its orifice, unlike that of the superior cava, is provided with a remarkable semilunar valve, the *valvula Eustachii* (*n*), which surrounds the anterior half, and sometimes two thirds of this opening. Its free margin is concave, and directed upwards; its adherent border is convex, and directed downwards; one of its surfaces is turned forwards towards the auricle, the other backwards towards the vessel; one of its extremities appears to be continuous with the margin of the fossa ovalis (*s*), and the other is lost upon the margin of the opening of the inferior cava.

The valve of Eustachius closes the orifice of that vein very imperfectly. In its upper two thirds it is extremely thin, and resembles the valves of the veins; its lower third contains a muscular fasciculus.

The *orifice of the coronary vein* is placed immediately in front of the preceding, from which it is separated by the Eustachian valve. It is sometimes situated at the bottom of a small cavity or vestibule. It is provided with a very thin semilunar valve (*valvula Thebesii;* below and behind the bristle), which exactly resembles the valves of the veins, and completely covers the mouth of the vessel. The upper extremity of this valve is continuous with the lower end of the Eustachian valve.

The inter-auricular orifice. In the fœtus, the inter-auricular septum is perforated behind and below by an opening improperly called the *foramen of Botal*, for it was known to Galen, who described a free communication between the auricles. After birth, we find in the situation of the foramen ovale a fossa (*fossa ovalis, vestigium foraminis ovalis*), or rather a plane surface, which is generally smooth, but occasionally uneven, and as it were reticulated; it is bounded in front and above by a semicircular ridge or border (*s*), which is improperly called the *isthmus* or *annulus Vieussenii*, and may be regarded as a more or less perfect sphincter. Behind, the fossa ovalis is continuous with the vena cava inferior; the semicircular ridge or border of the fossa ovalis is formed by a curved muscular fasciculus, sometimes very thick, the concavity of which is directed backwards; the inferior extremity of the fasciculus is continuous with the Eustachian valve.

The fossa ovalis is frequently found to be prolonged beneath the semicircular border or annulus, so as to form a sort of cul-de-sac, the bottom of which is often perforated, and the handle of a scalpel may not unfrequently be introduced through this opening into the left auricle, although no morbid phenomenon may have been observed during life.

The fasciculated and reticulated portion of the auricle. Upon the internal surface of the auricle, to the right of the vena cava, are observed certain muscular fasciculi or fleshy columns (*musculi pectinati auriculæ*), which are directed vertically from the auricula towards the auriculo-ventricular orifice. These fasciculi adhere to the auricle on one side only; they are intersected by other oblique and smaller bundles, which give a reticulated aspect to the inner surface of the auricle.

Cavity of the auricula. The auricula, or that portion of the auricle which extends from the vena cava superior to the bottom of the appendix, consists of an areolar or cavernous structure, exactly resembling that which has been described in the ventricles. The same cavernous structure is found in other parts of the auricle, and in particular near the orifice of the coronary vein.

I agree with Haller* and Boyer, in denying the existence of the *tubercle of Lower*, described by that anatomist as situated (at *m*) between the openings of the venæ cavæ.

It is generally admitted, that a certain number of small veins open into the right auricle by minute orifices without valves. We find, in fact, some openings resembling vascular orifices, and known under the name of the

* "Id tuberculum cupide receptum est, ut fere fit, ab iis scriptoribus quibus occasio ad propria experimenta nulla est, deinde etiam ab iis qui tandem omninò in corporibus humanis dissecandis se exercuerunt." (Haller, *Elem. Phys.* t. i. lib. iv. sect. 2. p. 314.)

foramina Thebesii; they are constantly found below the orifice of the vena cava superior, but most of them only lead into small groups of areolæ, and injections do not demonstrate the existence of any corresponding vessels. The only true vascular orifices are those for the anterior coronary veins.

Interior of the Left Auricle.

The cavity of the left auricle (*fig.* 197.) differs from that of the right in the following circumstances: — in being less capacious than the right auricle, the proportion between them being four to five; in its form, which is irregularly cuboid; in the number of its orifices, of which there are five after birth, and six in the fœtus; in the character of those orifices: thus the left auriculo-ventricular orifice (see *fig.* 195.) is smaller than the right; its long diameter, which is transverse, is from thirteen to fourteen lines, its short diameter is from nine to ten lines; the four other openings belong to the pulmonary veins, two (*c*) on the right, and two (*c c*) on the left side, and all are without valves*; in the structure of its auricula, which is perfectly distinct from the rest of the auricle, and contains a central conical cavity, leading into the auricle by a well defined circular opening; in the left auricle, nothing is seen on the septum corresponding to the fossa ovalis.† When the two auricles communicate by an oblique passage, we find a very thin fibrous band, beneath which the scalpel may be introduced into the right auricle.

Structure of the Heart.

The heart is essentially a muscular organ, and has a framework consisting of certain fibrous rings or zones; it is covered by a layer of serous membrane; the left cavities are lined by a membrane continuous with the internal coat of the arteries, and the right cavities by one continuous with the lining membrane of the veins.‡ Some nerves, proper vessels, and cellular tissue, also enter into its structure.

The Framework of the Heart.

This term may be applied to four *fibrous zones* (the tendinous circles of Lower), which may be regarded as affording both origin and insertion to all the muscular fibres of the heart. These zones are situated at the four orifices of the ventricles, viz. the two auriculo-ventricular and the two arterial orifices.

Dissection. Remove with care the adipose tissue, and the vessels which occupy the furrows of the heart. Examine the fibrous zones from the internal surface of the heart. In order to study the relations of the orifices with each other, remove the auricles, the aorta, and the pulmonary artery, a little above those orifices.

The auriculo-ventricular zones. Each *auriculo-ventricular* zone is a tolerably regular fibrous circle, which surrounds the opening between the auricle and ventricle, and determines its form and dimensions. These fibrous circles give off expansions of a similar nature, which enter into the formation of the tricuspid and mitral valves, and thus add to their strength. The chordæ tendineæ of the heart also terminate in these zones, either directly or through the medium of the valves.

The left auriculo-ventricular zone is stronger than the right.

The arterial zones. These are two circular rings, the diameter of each of

* It is not uncommon to meet with five openings, three on the right and two on the left side; in other cases, the two left pulmonary veins open by a common orifice.

† [The situation of the fœtal opening (*a*, *fig.* 197.) is very commonly indicated by a recess of variable depth opening between the left surface of the septum and the (still free) crescentic border of the valve of the foramen ovale.]

‡ [The muscular fibres of the heart, though involuntary, very closely resemble in structure those of the voluntary muscles (see note, p. 249.), but the transverse striæ upon them are less distinct.

The lining membranes of the two sides of the heart are covered by epithelium, and form what is termed the *endocardium*.]

which is somewhat less than that of its corresponding artery, so that there are some very distinct folds or wrinkles produced. These two zones are exactly alike in form, but differ somewhat in strength, the aortic being stronger than the pulmonary. From these zones are given off three very thin but very strong prolongations, which occupy the angular intervals formed by the indented border by which the aorta and pulmonary artery commence; and three other prolongations extend into the substance of the sigmoid valves. These prolongations form very distinct fibrous bundles in the sigmoid valve of the aorta.

Relative position of the orifices of the ventricles (see *fig.* 195.). The two auriculo-ventricular orifices are situated upon the same plane, posterior to the other orifices, and approach each other at their middle.

The long diameters of these two orifices are at right angles to each other: thus the long diameter of the right auriculo-ventricular orifice is directed from before backwards, whilst that of the left orifice is directed transversely.

In the angular interval left between these two orifices in front, the aortic opening (*e*) is closely united to them both; so that the posterior half of the circumference of the aortic zone is blended with both auriculo-ventricular zones. At the point of junction between them, we find a cartilaginous, and in the larger animals a bony, arch, which was described by the ancients under the name of the *bone of the heart:* in this situation, also, we frequently find the ossiform concretions of the orifices.

Lastly, upon a plane in front and on the left of the aortic opening, and about five or six lines above it, is situated the orifice (*f*) of the pulmonary artery.

The orifice of the aorta is directed towards the right side, that of the pulmonary artery towards the left, so that these two vessels cross each other, so as to represent the letter X. It follows, therefore, that the pulmonary orifice is separated from the right auriculo-ventricular opening by the orifice of the aorta.

In examining these openings we observe, that the plane of the auriculo-ventricular orifices is directed obliquely backwards and downwards: this explains the difference in the heights of the ventricles before and behind. We also notice the reflection or turning inwards of the base of each ventricle (*q a*, *p b*) upon itself, so as to form a circular groove or trench on the inner surface of its cavity, running entirely round the margin of the corresponding auriculo-ventricular orifice.

The Muscular Fibres of the Heart.

The Muscular Fibres of the Ventricles.

Dissection. The muscular fibres of the heart may sometimes be traced without any preparation; but, generally speaking, either commencing putrefaction, maceration in vinegar, or still better hardening and separation of the fibres by means of alcohol, and especially by boiling, are necessary for this purpose. This being done, remove first the outer membrane, and then the different muscular layers one by one, taking care to follow the fibres from their origin to their termination.

The most general formula which can be given respecting the structure of the ventricles is, that *this portion of the heart is composed of two muscular sacs, contained within a third, which is common to both ventricles.* We should add, that, when the superficial or common fibres arrive at the apex of the heart, they turn up so as to pass into the interior of the ventricles at that point, and form the deep fibres of these two cavities, so that the proper fibres of each ventricle are situated between the direct and the reflected portion of the common fibres.

We shall now enter into some details regarding these fibres.

All the muscular fibres arise from the fibrous zones, and they all terminate upon them, as was clearly pointed out by Lower.* They do not consist of short fibres placed end to end, but are of considerable length, descending in one part of their course, and ascending in the other. The muscular fibres are ranged in successive layers, which pass as it were into each other. The muscular fasciculi of each layer are not distinct from one another, but they mutually send off fibres by which they are bound together like the pillars of the diaphragm; or it may be said, that they intersect each other at very acute angles; it is therefore impossible to calculate the number of layers, which, according to Wolff, are about three in the right ventricle and six in the left. All that we are able to determine is, the different sets of fibres which enter into the formation of the heart, and of these we find that there are two sets, one *common*, the other *proper* fibres.

The superficial common fibres. All the superficial fibres are common to the two ventricles, and all are oblique and curved; they commence at the base of the heart, and pass obliquely in a spiral manner towards the apex. All the superficial fibres of the anterior region of the heart pass from the right to the left side; all those of the posterior region from the left to the right side. There are neither vertical nor horizontal fibres in the heart, as some authors have stated. The arrangement of the fibres at the apex of the heart forms, as it were, a key to the structure of the entire organ. The anterior and the posterior superficial common fibres both converge towards that point. Each of these sets of fibres forms a very distinct fasciculus or band, and the two bands mutually turn round each other in a semi-spiral direction, so that the anterior band is embraced on the left side by the posterior, which is in its turn embraced by the anterior band on the right side; from the apex of the heart the fibres change their course, and instead of descending, they ascend; and instead of being superficial, they become deep-seated. Having entered the heart at its apex, they continue to be reflected upwards, and present an arrangement which I shall describe, after having explained the course of the proper fibres.

The proper fibres. These are situated between the superficial or descending, and the deep or ascending portion of the common fibres. They form in each ventricle a sort of small barrel or truncated cone, which is applied to that of the opposite ventricle: the superior openings of these cones correspond to the auriculo-ventricular orifices; while the inferior, which are smaller, leave opposite the apex of the heart two considerable intervals, which are filled up by the common fibres. Do these proper fibres turn round and round without end, like an uninterrupted spiral, as Senac was inclined to believe? It appears to me, that their extremities are attached to the auriculo-ventricular zones, and that they describe more or less complete circles, which intersect each other at very acute angles.

The reflected or deep common fibres. The superficial common fibres are reflected at the apex of the heart, and penetrate into its interior through the lower orifices of the small barrels or cones, formed by the proper fibres. In this situation the anterior and posterior bands, by being reflected upwards, and mutually turned round each other, form at the apex of the heart a sort of *star with curved rays.*

Nothing can be more evident than the reflection or turning up of the fibres; it was pointed out, though vaguely, by Vesalius, but has been most explicitly described by Steno, who stated expressly that the external fibres enter the heart at the apex, and assuming an opposite direction to their former one, become the innermost layers, and who compared the apex of the heart to a star. It was also described by Lower, who has accurately figured a radiated structure at the summit of each ventricle; by Winslow, who says that the super-

* The same arrangement occurs in regard to the fibres of the auricles; it follows, therefore, that the muscular fibres of the ventricles are not directly continuous with those of the auricles.

ficial fibres enter the heart at its apex; and by Wolff and Gerdy, who state that the fibres of the heart are twisted into a whorl or vortex.

From the turning back and the lateral twisting of the anterior and posterior bands it follows, that, by removing the serous membrane which covers the apex of the heart, we may, without injuring the fibres, penetrate into its interior at two points, one to the right, and the other to the left of the anterior band.

The deep reflected fibres having thus reached the interior of the ventricles. pass on the inner side of the proper fibres, and are arranged in three perfectly different modes: thus, some form simple loops with the superficial portion, others are arranged like the thread of a screw, or the figure 8, and others constitute the columnæ carneæ.

The *looped fibres*, noticed by Winslow under the name of the bent or arched fibres, and so well described by Gerdy, form by their superficial and their deep portions the opposite walls of the ventricle: thus, the anterior superficial fibres constitute by their reflection the deep layer of the posterior wall, whilst the posterior superficial fibres, after being reflected, form the deep layer of the anterior wall.

The fibres, arranged like the thread of a screw, or like the figure 8, with its lower ring extremely narrow, have been accurately described and even figured by Lower, and were improperly rejected by Winslow, Senac, and others. The superficial portion of these fibres exactly resembles that of the looped fibres, and are always twisted after their reflection, so that their deep portion belongs to the same wall as their superficial. Thus, those fibres whose superficial portion belongs to the anterior wall of the ventricle, assist in forming the same wall by their deep portion.

The *columnæ carneæ* of the heart are formed by a certain number of fibres reflected in loops, or like the figure 8.

Such is the arrangement of the muscular fibres of the ventricles.*

The Muscular Fibres of the Auricles.

The auricles, like the ventricles, *have common and proper muscular fibres.* There is only one fasciculus of common fibres; it occupies the anterior surface of both auricles, and extends transversely from the right to the left auricula. The proper fibres constitute a very thin muscular layer for each auricle; they all commence and terminate at the corresponding ventricular zone.

The proper fibres of the left auricle. The muscular layer in this auricle is continuous and uniform and not areolar. It consists of circular fibres, which occupy the neighbourhood of the auriculo-ventricular orifice, and all the anterior region of the auricle; and of oblique fibres, also arising from the auriculo-ventricular orifice, and divided into several very distinct loops. One circular loop passes between the auricula and the left pulmonary veins; a second forms a vertical zone, interposed between the right and left pulmonary veins; it is very broad, and occupies the entire interval between the veins of the right and left side; a third and a fourth, very small, are interposed between the two pulmonary veins of each side. These fasciculi, by changes in their direction, become adapted to the circular form of the orifices, and constitute true sphincters. It would appear that, besides these bundles, there are some proper circular fibres around each orifice.

The proper fibres of the right auricle. In the right auricle the fleshy fibres do not form a continuous layer. This auricle may be regarded as consisting

* The arrangement described above is common to both ventricles. In the right ventricle almost all the reflected fibres enter into the columnæ carneæ. There is no interlacing, or indigitation of the fleshy fibres along the anterior and posterior furrows, as has been stated; still less do we find a raphé in the situation of these furrows. The splitting and separation of the muscular fibres, caused by the entrance of the bloodvessels opposite the furrows, and the condensation of the fibres between the openings for the vessels, have occasioned these erroneous views.

in the first place of a non-muscular portion, which may be called the *confluence of the venæ cavæ* (*sinus venosus*); in it there is only one small muscular bundle situated immediately to the right of the orifice of the vena cava superior; and secondly of a muscular portion, which resembles a sort of grating and is comprised between two fasciculi, one a circular bundle, surrounding the auriculo-ventricular orifice; the other a very prominent semilunar bundle, interposed between the vena cava inferior and the auricula, and forming a vertical or rather an oblique arch, which terminates to the right of the inferior cava.

Muscular fibres of the auriculæ. The walls of the left auricula present a cavernous or areolar structure, in the middle of which we see a central canal, which opens into the interior of the auricle by a distinct orifice. There is not in general any central canal in the right auricula, but only an areolar or cavernous structure.

The muscular fibres of the inter-auricular septum form a muscular ring for the border of the fossa ovalis (so incorrectly termed the *isthmus* or *annulus of Vieussens*), which must be regarded as a true sphincter, consisting of two thirds, three fourths, or even an entire circle. The fibres of which it is formed arise from the auriculo-ventricular orifice, near the septum. Some muscular fibres are often found in the substance of the floor of the fossa ovalis. The other muscular fibres of the septum are continuous with the circular fibres of the auricles.

Separation of the Two Hearts.

Dissection. Divide the anterior fibres of the ventricles carefully, layer by layer, parallel to the anterior furrow. Then separate the two ventricles, by means of the finger or the handle of the scalpel. In order to separate the auricles, carry the scalpel along the posterior inter-auricular furrow, being particularly careful upon arriving at the fossa ovalis. It is often possible to separate the auricles completely without opening either of them.

The division of the heart into the *right* and the *left heart* is not merely imaginary or theoretical, but is capable of actual demonstration. After making the beautiful preparation described above, we find that the left convex ventricle is received into a corresponding concavity in the right ventricle; the two are therefore adapted to each other, and their mutual reception is rendered complete by means of the infundibuliform prolongation of the right ventricle.

On the other hand, the right auricle is convex, and is received into a corresponding concavity in the left auricle.

By placing the two halves of the heart together, we see clearly the position of the aortic opening behind and to the right side of the pulmonary, the crossing of the aorta and the pulmonary artery in the form of the letter X; the relation of the aorta with the base of the right ventricle, and its situation between the right auriculo-ventricular orifice, which is behind, and the infundibuliform prolongation of the right ventricle, which is in front of it. This last relation explains how a communication may take place between the aorta and the right ventricle.

The separation of the two sides of the heart also enables us to judge accurately of the shape and the relative size of the two ventricles, the regular conical form of the left ventricle, the prismatic and triangular form of the right ventricle, the left wall of which is as it were pushed inwards by the corresponding projection of the left ventricle. We can also ascertain the shape and relative size of the two auricles.

Vessels, Nerves, and Cellular Tissue.

Arteries. The heart receives certain proper arteries, called *cardiac* or *coronary*, from their being arranged in the form of a circle or crown. They are two in number, and are the first branches given off by the aorta. They form

two arterial circles placed at right angles to each other; that is to say, one circle follows the auriculo-ventricular furrow, and the other occupies the inter-ventricular furrow.

Veins. Corresponding to these two arteries, there is one vein, named the *great cardiac* or *coronary vein*, and a few small ones, called the *anterior coronary veins.* I do not think that the existence of those accessory veins described by Thebesius as terminating directly in the right auricle, and the other cavities of the heart, has been clearly demonstrated. I have already said that the common openings of several groups of areolæ have been often mistaken for the orifices of veins. There is always an opening resembling the orifice of a vein below the vena cava superior, but injection does not show any vessel there.

Lymphatics. These terminate in the numerous lymphatic glands, which surround the bronchi and the lower part of the trachea.

Nerves. The *cardiac nerves* are small when compared with the nerves received by other muscular organs, with those of the tongue for example, and especially with those of the muscles of the orbit. Some are derived from the cervical ganglia of the sympathetic nerves, the others from the cerebro-spinal system, viz. the cardiac branches of the pneumogastric.

These nerves, which are placed near the arteries, follow them at first, but soon separate from them, and are lost in the muscular substance. We cannot therefore admit the opinion of Behrends, who attempted to prove that the nerves are intended only for the vessels of the heart, and not for its proper tissue.

Cellular tissue. The serous cellular tissue which unites the muscular fasciculi of the heart is so delicate, that it is extremely difficult to demonstrate it. In certain cases of disease it may become loaded with fat.

We always find a greater or less amount of fat upon the surface of the heart beneath the serous membrane; it abounds in the circular furrow between the auricles and ventricles, in the furrow of the ventricles, at the apex and right border of the heart, in the furrow between the pulmonary artery and the aorta, and between the small digital appendages upon the top of the left auricle.

Developement.

In size. The heart is larger in proportion to the rest of the body in the earlier stages of its developement.

In the fœtus at the full term, and after birth, the weight of the heart is to that of the body as 1 to 120; before the end of the third month of intra-uterine life it is as 1 to 50. It should be remembered that, at the fourth or fifth week, the heart of the fœtus occupies the entire cavity of the thorax. In old age the heart does not undergo atrophy like most of the other organs, and in many subjects far advanced in years it is even hypertrophied.

In direction. During the first three months the heart of the fœtus is directed vertically as in other mammalia; it does not begin to deviate to the left side and forwards, as in the adult, until the fourth month.

*In shape.** The heart at an early period forms a rounded and symmetrical mass, of which the auricles constitute the greatest part; the ventricles appear at this time to be only appendages of the heart, and the right auricle alone is equal in size to all the rest of the organ. The ventricles are gradually enlarged, whilst the auricles diminish, and towards the fifth month the due proportion between the auricles and ventricles is established; the left ventricle is, at this period, more capacious than the right. The walls of the heart are thicker than they are afterwards, and the heart is firmer and does not collapse when empty. The thickness of the parietes of both ventricles is almost the same.

In internal conformation. It is in reference to its internal structure that the principal changes occur during the developement of the heart. The right

* See note, p. 656.

and left sides of the heart communicate freely during the whole period of intra-uterine existence. The inter-auricular septum does not exist, or at least only in a rudimentary state during the earlier months of fœtal life.

Is there any period of fœtal existence during which the inter-ventricular septum is entirely wanting? and does the developement of the human heart, which would then resemble the heart of reptiles, coincide with the general law by which the organs of man, before acquiring their perfect form, pass successively through the several conditions represented by the corresponding organs in the lower animals? The observations of Meckel, which extend as far back as the fourth week, prove that the inter-ventricular septum always exists at that period, but that it is imperfect at the upper part, where it is perforated or notched.*

Cases of malformation, in which the septum of the ventricles is absent, cannot be quoted in support of the opinion, that the septum is wanting in the early periods of life; for it would be necessary to prove that such a malformation is an arrest of developement.

The opening between the two auricles becomes contracted, and forms the foramen ovale (or *foramen of Botal*), which is found at the posterior and inferior part of the septum.

The valve of Eustachius is sufficiently broad to separate the orifice of the vena cava inferior from the cavity of the right auricle, so that the blood of that vein is carried directly into the left auricle.

Towards the end of the third month, the valve of the foramen ovale, which afterwards forms the bottom of the fossa ovalis, begins to appear; it arises from the posterior half of the opening of the vena cava inferior. About the same period the Eustachian valve decreases in size, and from this time the developement of these two valves proceeds inversely, that is to say, the Eustachian valve diminishes, whilst that of the foramen ovale becomes larger. In consequence of this change, the vena cava inferior no longer opens into the left auricle, but into the right.

At the fifth month the foramen ovale is almost entirely closed by the valve which grows from below upwards, and from behind forwards; at a later period it projects into the left auricle, beyond the margin of the foramen ovale, so that there is an oblique passage from one auricle to the other. After birth, adhesion takes place between these parts; but even when this does not occur, the obliquity of the passage is such, that the want of adhesion does not necessarily allow of any admixture of the blood of the two auricles.

Function.

The heart is the agent by which the blood is impelled through the vessels. The venous blood is poured into the auricles, which then contract; part of the blood flows back into the veins, but the greater portion passes into the ventricles, which contract in their turn. The auriculo-ventricular valves meet, and prevent the reflux of the blood into the auricles, and it is therefore propelled into the arteries. The sigmoid valves at first lie in contact with the

* [The researches of modern embryologists have shown that the heart, in its simplest condition, consists of a straight tube, which is placed vertically in the body, receives the veins at its inferior extremity, and gives off the arteries from its superior extremity. The lower or venous end soon turns upwards, so that the tube becomes bent into a loop, which for a time projects through a cleft on the anterior aspect of the body. The tube then becomes divided into an auricular and a ventricular portion, and into a bulbus arteriosus, all enclosed in a pericardium; and in this state the heart of the human fœtus corresponds with the permanent condition of this organ in fishes. Each of these three portions becomes again subdivided; the auricular portion by a descending septum into the two auricles, the ventricular by an ascending septum into the two ventricles, and the bulbus arteriosus into the aorta and pulmonary artery. For a certain period the right and left auricles, and the right and left ventricles, communicate with each other. When the septum between the ventricles is yet imperfect (a condition which is permanent in reptiles generally), the common ventricular cavity gives origin to both the aorta and the pulmonary artery. Before the middle of fœtal life, this septum is completed, and then the two vessels arise each separately from its proper ventricle. The septum between the auricles remains imperfect until after birth, when the foramen ovale at length becomes closed.]

walls of the arteries, so as to permit the blood to pass from the ventricles; they then fall down at the moment when the distended arteries re-act upon their contents, and thus prevent the reflux of the blood into the ventricles. The contraction and dilatation of the heart have been termed its *systole* and its *diastole*.

The two auricles contract simultaneously; so also do the two ventricles. The dilatation of the auricles occurs during the contraction of the ventricles, and *vice versâ*. Dilatation is not an active phenomenon, for the fibres of the heart are so arranged, that they can produce shortening and contraction of this organ, but can neither elongate nor dilate it.

The spiral arrangement of the fibres shows that the twisting motion of the heart described by the ancients is not so devoid of foundation as at first sight might be imagined.

It has been stated, but without proof, that the ventricles perform a kind of swing movement, in consequence of which the apex of the heart is carried forwards.

The sounds of the heart probably result from friction of the blood against the arterial and auricular orifices, and not from contraction of the muscular fibres, nor from the apex striking against the parietes of the thorax, nor from the percussion of the blood against the walls of the heart.*

THE PERICARDIUM.

The *pericardium* (*p p*, *fig.* 170.) is a fibro-serous sac, which surrounds and protects the heart.

Congenital absence of the pericardium is extremely rare: complete adhesion of the pericardium to the heart, or cellular transformation of this membrane, have been most commonly mistaken for such malformation. Nevertheless, I have seen the heart of an adult to which there was no pericardium: this anomaly has been figured by M. Breschet. The heart was free from any adhesion, and occupied the cavity of the left pleura.

The older anatomists, and particularly Senac, attempted to determine exactly how much larger the cavity of the pericardium is than the heart, Having injected water into the pericardium in different subjects, this observer found that the quantity of liquid contained between the heart and its covering varied from six to twenty-four ounces. I have satisfied myself that in the healthy state, the capacity of the pericardium exactly corresponds to the size of the heart when that organ is dilated to the utmost. In certain cases of hydrops pericardii, this sac becomes enormously enlarged: on the other hand, its inextensibility explains the syncope which immediately follows rupture of the heart †, and which is produced by the accumulation of a small quantity of blood in the pericardium. The syncope which accompanies the effusion from acute pericarditis, probably depends upon a similar cause.

Form. The pericardium is shaped like a cone, with its base downwards and its apex upwards. It has an external and an internal surface.

* [The action of the heart is accompanied by two distinct sounds; the first is synchronous with the pulse in the immediate vicinity of the heart, and, consequently, with the contraction of the ventricles; the second is more abrupt and clear, and immediately succeeds the first.

According to the prevalent opinion, the first sound depends essentially upon the muscular contraction of the ventricles, increased and modified by the closure of the auriculo-ventricular valves, by the passage of the blood over the internal surface of the ventricles, and by the stroke of the heart against the ribs. The second sound is generally believed to be produced by the tension of the sigmoid valves at the root of the aorta and pulmonary artery, in consequence of the re-action of the column of blood against them. Since the opinion given in the text was written, M. Cruveilhier has had an opportunity of studying the motions and sounds of the heart in a case of malformation in which that organ was exposed on the fore part of the chest; and he is led to infer that both sounds are produced by the sigmoid valves; the second by their expansion, and the first by the opposite movement from the centre to the sides of the arteries.]

† Death from rupture of the heart is not produced by hæmorrhage, for often we do not find more than seven or eight ounces of blood escaped; but it is caused by compression of the heart, in consequence of the inextensibility of the pericardium.

External surface. The pericardium is situated in the mediastinum, and has the following relations:—

In *front*, it corresponds to the sternum and the cartilages of the fifth, sixth, and seventh ribs on the left side, from which it is separated by the pleura and the lungs; in the middle, it is separated from the sternum by some cellular tissue only. The pericardium is in more or less immediate relation with the sternum, according to the size of the heart, or the quantity of fluid in the pericardium. *Behind*, it corresponds to the vertebral column, from which it is separated by the posterior mediastinum and the organs contained in it, viz. the œsophagus, the aorta, the thoracic duct, &c. *On the sides*, it is in immediate relation with the pleuræ, and indirectly with the lungs. The phrenic nerves and the superior phrenic arteries are applied along the sides of the pericardium. The *base* corresponds to the cordiform tendon of the diaphragm, and to the muscular fibres on the left side of it. It adheres closely to the diaphragm, only in the anterior half of its circumference; in every other part the base of the pericardium may be easily detached. The *apex* is prolonged upon the great vessels which enter and pass out at the base of the heart.

The pericardium is covered by the pleuræ in the greatest part of its extent, and is united to them by cellular tissue, which is tolerably dense at the sides, and very abundant in front and behind. The cellular tissue of the anterior mediastinum is often loaded with fat, as well as that which surrounds the base of the pericardium, where it sometimes forms prolongations resembling the appendices epiploicæ upon the large intestine.

The *internal surface* of the pericardium is free and lubricated by serosity, like the inner surface of all serous cavities.

Structure. The pericardium is a fibro-serous membrane analogous to the dura mater, and, like it, is composed of two very distinct layers, one external and fibrous, the other internal and serous.

The *fibrous layer* consists of fasciculi interlacing in all directions. It is extremely thin, and from its adhesions to the cordiform tendon of the diaphragm, it has been regarded as a prolongation of that structure, but it adheres closely to the diaphragm only in front, and much less intimately in the fœtus and the new-born infant. In consequence of this adhesion, the pericardium follows all the motions of the diaphragm.

The fibrous layer is prolonged upon the surface of the great vessels which open into the cavities of the heart, and furnishes for each of them an indistinct sheath, which is soon lost upon them.

The *serous layer* of the pericardium, like serous membranes generally, forms a shut sac, adherent by its outer surface, but free and smooth internally.* After having lined the fibrous layer, it is reflected upon the great vessels at the base of the heart, and then covers the heart itself, of which it forms the external membrane. We shall consider it as consisting of a parietal, and a visceral or reflected portion.

The parietal portion. The fibrous and the serous layer of the pericardium are so closely adherent, that it is very difficult to separate them. We shall find the same to be the case with the dura mater.

The reflected or visceral portion. The existence of this portion of the serous membrane can be shown most readily at the points where it is reflected from the fibrous membrane upon the great vessels. It forms one complete sheath, which is common to the aorta and pulmonary artery; some fat is often found in the furrow between these two vessels; it also forms two semi-sheaths for the venæ cavæ and the four pulmonary veins, which are thereby rendered smooth only in the anterior half of their circnmference. The heart is entirely covered by the serous membrane, which is here extremely thin. In fat hearts it is raised from the muscular fibres by some flakes of adipose tissue, like the appendices epiploicæ of the great intestine.

* Its inner surface is covered with epithelium.

Vessels and nerves. The *arteries* of the pericardium are very small; they are derived from the surrounding arterial branches, viz. the superior phrenic, the anterior mediastinal, and the bronchial. The *veins* accompany the arteries, and open into the brachio-cephalic veins. Several of them are also said to terminate in the coronary veins. The *lymphatic vessels* enter the lymphatic glands, which surround the vena cava superior.

No *nerves* have yet been demonstrated in the pericardium, though possibly they may exist.

THE ARTERIES.

Definition. — Nomenclature. — Origin. — Varieties. — Course. — Anastomoses. — Form and relations. — Termination. — Structure. — Preparation.

THE term *arteries* * is applied to the vessels which arise from the ventricles of the heart, and to their several divisions.

There are two systems of arteries, one of which commences at the right ventricle, whilst the other commences at the left. The primitive trunk of the first is the *pulmonary artery*, that of the second is the *aorta.*

These two arterial systems are perfectly distinct in the adult, but communicate freely, and form only one system in the fœtus.

The following general remarks apply more particularly to the aorta and its divisions:—

The *arteries* form an uninterrupted succession of decreasing canals, all arising from a common trunk. In this respect we may compare the entire arterial system to a tree, the trunk of which is the aorta, whilst the larger and smaller branches and the twigs are represented by the divisions which arise in succession from that vessel, as from their common origin.

Again, since the total area or capacity of all the arterial divisions greatly exceeds that of the aorta, we may also regard the arterial system as a cone, the base of which is situated in the entire body, and the apex at the aorta.†

The study of the arteries includes that of their nomenclature, origin, course, direction, relations, anastomoses, termination, and structure.

Nomenclature.

The nomenclature of the arteries leaves little to be desired in regard to precision; the names of these vessels are derived either from those of the parts to which they are distributed, as the thyroid, lingual, and pharyngeal arteries, &c.; or from their situation, as the femoral and radial arteries; or from their direction, as the circumflex and coronary arteries.

The limits by which one artery is distinguished from another immediately succeeding to it, may be either natural or artificial.

We may regard as *natural limits* the point of origin on the one hand, the point of division on the other, as in the common iliac and common carotid arteries.

The object of *artificial limits* is to enable us to establish certain divisions of the same arterial trunk, by which means we can describe its relations with greater accuracy. Thus we shall find successive portions of the artery of the upper extremity named the subclavian, the axillary, and the brachial artery.

* From ἀὴρ, air, and τηρεῖν, to keep. The etymology of this term affords us evidence of the error of the ancients, who, because they always found these vessels empty and patent after death, imagined that they contained air during life.

† Haller has collected all the comparative estimates that have been made between the area of the principal trunks and that of their respective divisions collectively. (*Elem. Phys.* t. i. p. 151—163.)

Origin of the Arteries.

The common origin * of the arterial system is the aorta, which arises from the left ventricle of the heart in the manner already indicated (see THE HEART); but the origins of the other arteries take place according to certain very general laws: thus, two arteries of equal size may arise from the extremity of a larger artery, and appear to result from the bifurcation of that vessel; arteries arising in this manner might be called *terminal arteries.* Other arteries arise from some point in the circumference of a larger vessel; these may be termed *collateral* arteries.

The terminal arteries almost always arise so as to form a bifurcation at an acute angle; the dichotomous division or bifurcation is the most common mode of division. The acute angle is evidently favourable to the passage of the blood, which in the first place maintains nearly the primitive direction in which it was impelled, and secondly is easily divided into two columns by the projecting crest at the angle of division.

The collateral arteries very often arise at an acute angle, but sometimes at a right or even at an obtuse angle. The two latter modes, especially the last, are unfavourable to the flow of the blood. It must however be remarked, that many of the arteries which follow a retrograde course in reference to the trunk from which they are derived, nevertheless arise at an acute angle. The caliber of the terminal arteries is very nearly proportional to that of the artery from which they are given off, but the collateral arteries bear no proportion to the caliber of their trunks. We shall see a remarkable example of this in the spermatic arteries, as compared with the aorta from which they arise.

It should also be observed, that the caliber of a principal trunk does not diminish in proportion to the branches which it supplies: in proof of this, observe the aorta as it enters the abdomen, and just before its division into the common iliac.

Anatomical Varieties of the Arteries.

No system of organs is more subject to anatomical varieties than the arteries. These varieties sometimes affect their origin only, sometimes their course, but hardly ever their termination. The study of these varieties is of great importance in surgery, both in reference to the ligature of arteries, and also to operations performed in their vicinity. †

Course of the Arteries.

The principal arteries generally follow the *direction* of the axis of the limbs. The secondary, tertiary, and further divisions pursue the most varied courses, subject to no particular rule.

The principal arteries are usually straight; but they present slight curves, which render the artery longer than the corresponding limb, and hence tend to prevent laceration during the movement of extension, when the curves merely become obliterated and the vessel undergoes no injurious stretching. The use of these curves in the arteries may be proved by comparing the opposite conditions of the vessels during extension and flexion of the upper and lower extremities.

* The word origin must not be taken here in its exactly literal sense; for it has by no means been shown that the arteries are developed from the heart towards the extremities. A very ingenious theory tends, on the contrary, to prove that developement proceeds from the extremities towards the heart.

† [For special information on the varieties in the distribution of the arteries, the reader is referred to Haller, *Icones Anatomicæ*, 1756; Murray, *Descriptio Arteriarum, &c.* 1783—98; Barclay, *Description of the Arteries, &c.* 1818; Tiedemann, *Tabulæ Arteriarum, &c.* 1822; and to R. Quain's *Anatomy of the Arteries, &c.* with drawings by J. Maclise, 1840, 1841.]

A great number of the arteries pursue a very distinctly tortuous course, which, as Haller remarks, is preserved by the surrounding cellular tissue, and which is connected with certain particular conditions of the organs to which they are distributed. Thus, we meet with very tortuous arteries in parts which are alternately subject to considerable dilatation and contraction; as, for example, the coronary arteries of the heart and of the lips.

Again, the serpentine course of an artery, by increasing its length in a given space, adds to the extent of surface from which collateral branches may arise. The curvatures of the internal maxillary and of the ophthalmic arteries evidently have this advantage; and it is highly probable, that the arch of the aorta may serve a similar purpose.

The arteries are tortuous in certain parts also, in which this arrangement would seem to diminish the force and rapidity of the current of blood; it cannot fail to be perceived that such is the intention of the curvatures described by the internal carotid and the vertebral arteries. Bichat, it is true, has objected to this, that, in a system of communicating and permanently distended canals, the curvature can have no influence upon the rapidity of the fluid circulating through them. But I would answer, that this principle, though true in reference to a system of inextensible tubes, is not so when applied to a system of dilatable canals like the arteries. In the latter case, in fact, part of the momentum acts against the curvature itself, and straightens it in a certain degree; and, in this way, there is a loss of some portion of the original momentum.

In some arteries this tortuous condition is acquired, in others it results from the progress of age. It proceeds from elongation of the arteries, which is itself produced in the following manner: — At each ventricular systole, the arteries tend to become elongated as well as dilated. In the aged, and especially in those whose heart is very powerful, this tendency to become elongated produces an actual and permanent elongation, as may be seen in the abdominal aorta and in the common iliac, the humeral, and the radial arteries, which in almost all old subjects present alternate curvatures, that are never met with in the infant and the adult. We may also consider as acquired the tortuous condition assumed by collateral arterial branches, after the obliteration of the main trunk.

Anastomoses of the Arteries.

During their course, the arteries communicate with each other by certain branches, which sometimes unite two different trunks, and sometimes form a connection between two parts of the same trunk. This mode of communication is called *anastomosis* (ἀνὰ, by, and στόμα, a mouth). There are several kinds of anastomoses.

Anastomosis by inosculation, or by loops, in which two vessels running in opposite directions open into each other by their extremities and form a loop.

Anastomosis by transverse communication, as when two parallel trunks are united by means of a branch at right angles to their own direction: for example, the anterior communicating artery of the brain.

Anastomosis by convergence, in which two arterial branches unite at an acute angle to form a larger artery, as in the union of the vertebral arteries to form the basilar trunk.

By means of the anastomosis by inosculation or by loops, which is the most common method of communication, uninterrupted collateral channels are established along the great arterial trunks, the place of which they may even supply. The existence of these anastomoses, and the power possessed by arteries of becoming enlarged, to an almost indefinite extent, originated the bold idea of attempting to tie even the largest arterial trunks.

Anastomoses by inosculation are sometimes useful in regulating the distri-

bution of blood*, and spreading out the origins of arteries over a more extended space. Thus, by means of several series of arches, the superior mesenteric artery gives off branches which proceed at right angles to the small intestine throughout its whole length.

Forms and Relations.

The arteries represent regular cylinders when they give off no branch, and cones, or rather a series of decreasing cylinders, when they gradually diminish by giving off a certain number of branches. Their cylindrical form, together with the looseness of the surrounding cellular tissue, preserves them from a number of accidents. Thus, the humeral and the femoral arteries glide over the head of the humerus and femur in dislocations of these bones; and so the carotid arteries, contrary to all apparent probability, sometimes escape uninjured in incised wounds of the neck.

The arteries have relations with many other parts. *With the bones*, being supported by them, and more or less closely approximated to them. Thus the aorta is applied to the vertebral column, and the arteries of the limbs, after escaping from the trunk, become applied to the corresponding bones, their course along which is marked by a depression, and against which they may easily be compressed (see OSTEOLOGY).

From the relations of the arteries with the articulations some important practical inferences are derived. The arteries always occupy the aspect of flexion; and as flexion is performed in the larger articulations of a limb alternately in opposite directions, the arteries are observed to alter their relative position, as it were to regain the aspect of flexion. This is seen in the femoral artery as it becomes popliteal, and also in the brachial, which at first lies in the cavity of the axilla, and then turns forwards at the bend of the elbow. In consequence of this arrangement, the arteries are protected by the habitual, and as it were instinctive, position of the limbs.

On the other hand, the proximity of certain arteries to articulations, and the absence of any curvatures in such situations, may explain the occurrence of rupture of these vessels in dislocation, and often also in immoderate attempts at reduction.

With the muscles. The muscles are the essential protectors of the arteries, which they separate from the skin. There are large cellular spaces in the centre of the limbs for the reception of the principal arteries, which are thus removed from the influence of external violence.

Most arteries have a special muscle, which may be termed their *satellite* muscle. Thus, the sartorius is the satellite muscle of the femoral artery; the sterno-cleido-mastoideus of the common carotid; the biceps of the brachial artery, &c.

With the skin. Some arteries are subcutaneous, or rather sub-aponeurotic, in a certain part of their extent; and in large arteries this is almost always at the point where they emerge from the trunk, as in the femoral artery. The arteries of the cranium are situated between the skin and the epicranial aponeurosis in the whole of their extent. The importance of these relations in reference to compression of the vessels may be easily conceived.

With the veins. The arteries are always in relation with certain veins, which are applied to them. When there are two satellite veins (*venæ comites*) for one artery, the latter vessel is constantly placed between the two veins.

With the nerves. The arteries support the plexuses of nerves distributed to the organs of nutritive life. We may even regard their plexuses as forming an accessory coat to this set of vessels. Other nerves, though not so immediately in contact with the arteries, have a constant relation with them. This it is of im-

* [The retia mirabilia of arterial vessels, found in some animals, are examples of the repeated subdivision and anastomosis of arteries.]

portance to know, so that the nerves may be avoided, or that they may direct the operator in applying a ligature to the vessels themselves. For each artery it may be said there is one satellite nerve.

With the aponeurotic sheaths. The principal artery of a limb is provided with a fibrous sheath, which belongs to it in common with its veins, and often with its accompanying nerve. When an artery perforates a muscle, it is protected in its passage by a sheath or aponeurotic arch, which prevents, or at least moderates, the compression during the contraction of the muscle.

Lastly, the arteries are surrounded by a loose cellular sheath, which allows of their dilatation and their alterations in position. The looseness of this cellular tissue favours the displacement of arteries during the infliction of wounds, and enables us to isolate these vessels by blunt instruments, which cannot injure them.* As the nutritious vessels reach the coat of the arteries through this sheath, we can easily understand the impropriety of separating the vessel from it too extensively in tying the arteries.

Termination of the Arteries.

The divisions of the arteries are not so numerous as would at first sight appear. The number of successive divisions, commencing at the aorta, is not more than twenty.

The arteries terminate in the substance of organs. The number of arteries distributed to each organ is in proportion to the activity of its functions; secreting organs are much more plentifully supplied with vessels than those in which the function of nutrition only is performed. Soemmerring, Prochaska, and others, have observed that the actual termination of the arteries is different in different organs. Referring for further details upon this subject to textural anatomy, I shall content myself with stating here, that the arteries terminate in the capillary system, through the medium of which they become continuous with the veins.

Structure of Arteries.

The walls of an artery are composed of three coats: an external, a middle, and an internal.

The external coat. This is generally called the *cellular coat,* because it is in some measure continuous with the surrounding cellular tissue. Scarpa erroneously regarded it as not forming an integrant part of the arteries. It consists of a filamentous, areolar, and as it were felted tissue, which is never charged with fat, or infiltrated with serum, and which appears to me to present all the characters of the dartoid tissue. I believe that the contractility which has been attributed to the middle coat, is altogether dependent upon this. It is the only coat which remains undivided after the application of a ligature.

The proper or middle coat. The characteristic properties of arteries are chiefly dependent upon this coat. It is composed of circular fibres, which interlace at very acute angles, but which do not present the spiral arrangement admitted by some authors. From its yellow colour and its elasticity, it has been called the *yellow* or *elastic coat.* It is extensible longitudinally and transversely. It is very fragile, is easily torn by longitudinal extension, and is cut by a ligature. It is proportionally thinner in the great than in the small arteries. This coat is of the same nature as the yellow elastic ligaments, and is therefore not muscular. Moreover, chemical analysis shows that it contains no fibrine; direct irritation developes no contractility in it; and the supposed phenomena of irritability pointed out by Haller may be entirely attributed to elasticity.

The internal coat. It is a transparent pellicle of extreme tenuity; it must

* [Another important result of this is, that a divided artery is enabled to retract within its heath. In the abdomen and head, this sheath scarcely exists.]

be carefully distinguished from the subjacent layer, which is almost always dissected off with it. It is of a pale pink colour, and is lubricated with serosity. It appears to be of the nature of serous membranes, of which it presents the chief characteristics, viz. tenuity and non-vascularity.*

Vessels and nerves. The arteries and veins distributed to the coats of the arteries are called *vasa vasorum.* In regard to the question, whether the arteries receive any nerves, or whether the nervous plexuses which accompany them are only intended for the organ to which the vessels are distributed, I would observe, that the latter opinion appears to me to be the more probable.

Preparation.

The preparation of an artery consists in separating it from the neighbouring parts, at the same time preserving its relations. Most of the arteries may be studied without any other preparation than a careful dissection; but injections are necessary, in order to follow the smaller branches. The most convenient injection with which I am acquainted is the following †: — Tallow, nine parts; Venice turpentine, one part; ivory black, mixed with spirits of turpentine or varnish, two parts.

The best injection for preparations intended to be preserved is wax, one part; tallow, three parts; vermilion, indigo, or Prussian blue, first mixed with spirits of turpentine.

It is advantageous before making the general injection, to throw in some turpentine or spirit varnish, coloured with the substances mentioned above.

For a very fine injection it is necessary to use glue-size, coloured either with lamp-black, or vermilion.

In order to place a tube in the aorta, saw through the sternum longitudinally; keep the two halves apart by means of a small piece of wood; open the pericardium; be careful not to mistake the pulmonary artery for the aorta; raise up the aorta by a ligature; make an incision in it anteriorly, and introduce the pipe.

In injecting the coronary arteries, the pipe must be introduced into one of the carotids.

DESCRIPTION OF THE ARTERIES.

THE PULMONARY ARTERY.

Preparation. — Description. — Relations. — Size. — Developement.

Preparation. In order to inject the pulmonary artery, the injecting pipe must be introduced into one of the venæ cavæ.

The *pulmonary artery*, called *vena arteriosa* by the older writers, because having all the external characters of an artery; it nevertheless contains black blood, extends from the right ventricle to the two lungs. It arises (*k*, *fig.* 191.) from the infundibuliform prolongation of the right ventricle, and then passes upwards and to the left side, crossing in front of the aorta, which is embraced by its concavity; having reached the left side of this artery, after a course of about fourteen or fifteen lines, it divides into two trunks (*k k*, *fig.* 192.), which proceed transversely, one to the right the other to the left lung (*k k*, *fig.* 171.), where they terminate by dividing into branches. From the point of division into the right and left branches ‡ a fibrous cord, the remains of the ductus arte-

* [It consists of longitudinal fibres, which are slightly interlaced, and are covered with a squamous epithelium. The longitudinal wrinkles observed in arteries contracted after death, are produced in this coat.]

† [The paint or cold injection is one of the most useful; it consists of either red or white lead, mixed as a paint, with a small quantity of boiled linseed oil, with spirits of turpentine, and also with some driers, viz. sugar of lead, and litharge.]

‡ See note, p. 665.

riosus, proceeds in the original direction of the artery, and is attached to the concavity of the arch of the aorta opposite the left subclavian artery.

At its origin the pulmonary artery is covered externally by the highest fibres of the infundibulum; internally it is provided with three sigmoid moveable valves (*a a a*, *fig.* 196.), which, when depressed, completely close the mouth of the vessel. By careful dissection it is found, that the pulmonary artery is cut at its origin into three festoons, corresponding to the sigmoid valves, and that it is connected to the tissue of the heart by its internal coat, which is continuous with the lining membrane of the right cavities of the heart; and also by prolongations given off from the fibrous zone, and attached to the convex borders of the three festoons, and to the angular intervals between them.

Relations. In front and on the left side the pulmonary artery is convex, and covered by the serous layer of the pericardium, which is often separated from it by some fat; behind and on the right side it is concave, and is in relation with the aorta, which it embraces. The right and left auricles are in contact with its corresponding sides.

Size. The left branch of the pulmonary artery is about one inch in length; it is in relation behind with the left bronchus, one of the bronchial arteries often passing between them; it is in indirect relation with the aorta. In front, it is covered by the serous layer of the pericardium, excepting near the lungs, where the pulmonary veins are placed in front of the arterial branches.

The right division of the pulmonary artery is from sixteen to eighteen lines in length; it is in relation in front with the vena cava superior, and with the ascending portion of the aorta, but not immediately, for the serous layer of the pericardium covers both the aorta and the corresponding part of the pulmonary artery. Behind, it is in relation with the right bronchus, and passes above the right auricle.

Developement. In the fœtus, instead of the fibrous cord, which we have described as proceeding from the point at which the pulmonary artery divides into its two branches *, there is a canal called the *ductus arteriosus*, almost equal in diameter to the pulmonary artery itself, the course of which vessel it pursues; at this time the right and left branches of the pulmonary artery are very small. At birth the whole of the venous blood proceeds to the lungs, none of it passing through the ductus arteriosus, which then becomes obliterated.

THE AORTA.

Preparation. — Definition. — Situation. — Direction. — Size. — Division into the arch of the aorta, the thoracic aorta, and the abdominal aorta.

Preparation. The aorta may be studied without having been injected.† In order to study it in an injected subject, the median incision made for the purpose of introducing the injection must be prolonged down to the pubes. Then disarticulate the clavicles, separate the two sides of the thorax, even so far as to break some of the ribs, and keep them separate by introducing a piece of wood; cut through the abdominal parietes, and turn the left lung over to the right side.

The *aorta* (ἀορτὴ, *arteria magna*, *arteriarum omnium mater*; *a b c d*, *fig.* 198.), the common origin of all the arteries of the human body, commences at the left ventricle, and terminates by bifurcating (at *d*), opposite the fourth lumbar vertebra.

Situation. It is situated deeply in the thoracic and abdominal cavities, along

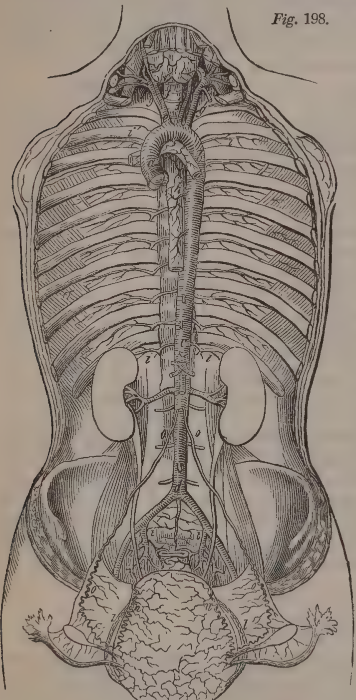
* [It was noticed by Haller and Senac, that the ductus arteriosus in the fœtus, and the cord to which it is reduced after birth, arise not from the angle of division into the right and left pulmonary arteries, but from the left pulmonary artery itself: this is an interesting and important fact in reference to the developement of the great vessels issuing from the heart.]

† It will be advantageous to study the aorta in the same subject in which the viscera have already been examined.

the vertebral column, which affords it both support and protection. In those animals in which the aorta is prolonged beyond the trunk, the vertebral column accompanies the vessel, and forms a bony canal or sheath for it, distinct from the canal for the spinal cord.

Direction. Immediately after its origin the aorta advances towards the right side (*a*, *fig.* 198.), and almost directly afterwards proceeds upwards describing a slight curve, the convexity of which is turned forwards and to the right, and the concavity backwards, and to the left.

Fig. 198.



After leaving the pericardium it changes its direction, becomes suddenly curved, and passes almost horizontally from the right to the left, and from before backwards, to reach the left side of the vertebral column, on a level with the third dorsal vertebra, at which point (*b*) it makes a third curve, and becomes vertical and descending. Having reached the diaphragm (at *c*) it inclines a little to the right side, in order to gain the median line, and to pass through the ring, or rather the canal, formed for it by the pillars of the diaphragm. From this point to its termination it rests upon the middle of the anterior surface of the vertebral column.

Varieties in its direction. It is not a very rare occurrence to find the aorta curving over to the right instead of the left side — a disposition which may either be accompanied with a complete transposition of the thoracic and abdominal viscera, or may be independent of it.

Size. The several portions of the aorta have not a uniform caliber *; but its gradual decrease, in this respect, bears no direct proportion to the number and size of the branches given off from it.

At its origin it always presents three ampullæ, which correspond to the sigmoid valves; they are called the *sinuses of the aorta*, or *sinuses of Valsalva.* They exist originally, and must therefore be distinguished from a dilatation found on the convex side of the arch of the aorta in old subjects, and called the *great sinus of the aorta.* This dilatation results entirely from the impulse of the current of the blood.

The caliber of the aorta, moreover, differs exceedingly in different subjects, even when there is no appreciable organic lesion †: it should be remarked, however, that the thickness of its coats is not at all in proportion with its caliber.

The aorta is generally divided into three portions, viz. the *arch* of the aorta,

* Thus the caliber of the commencement of the aorta, compared with that of its termination, is generally as five to three; hence the diminution is not by any means proportionate to the number of branches arising from it; for the united calibers of its collateral branches would much exceed that of the main vessels.

† Thus I have seen a case in which the aorta was 4 inches 8 lines in circumference opposite the arch, and 2 inches 6 lines at its lower end: the latter is the usual size of the vessel.

the *thoracic aorta*, and the *abdominal aorta*. The two latter portions form together the *aorta descendens*.

The Arch of the Aorta.

I shall give this name to all that part of the aorta (*a b*, *fig.* 198.) which is comprised between its origin from the left ventricle and the point where it is crossed by the left bronchus.*

The direction of the arch of the aorta is neither transverse nor antero-posterior, but oblique from the right to the left side, and from before backwards; so that it is anterior, median, and substernal in its first portion, and posterior at its termination, and in relation with the left side of the vertebral column. In consequence of these relations, aneurisms of the anterior part of the arch of the aorta frequently affect the sternum, whilst aneurisms of the posterior portion affect the vertebral column.

Relations. We shall examine the relations of the arch of the aorta, first in its pericardiac or ascending portion, and then in its horizontal and descending portions taken together.

The pericardiac portion (*f*, *fig.* 191.). Concealed, as it were, in the substance of the heart at its origin, it is in relation in front with the infundibulum of the right ventricle, and behind with the concavity of the auricles, which are moulded upon it. On the right, it rests upon the groove between the infundibulum and the right auriculo-ventricular orifice; on the left, it is in relation with the pulmonary artery. It is important to note the practical consequences of these relations. I have recently seen a communication between the aorta and the infundibulum. Again, aneurisms of the origin of the aorta may burst into the auricles.

After leaving the heart, this portion of the aorta is surrounded on all sides, but to a greater extent in front than behind, by the serous layer of the pericardium, which forms a sort of additional coat for it, excepting in front, below, and on the left side, where it is in immediate contact with the pulmonary artery, as that vessel turns round it. Behind, this portion of the aorta is in relation with the right division of the pulmonary artery; on the right, with the vena cava superior. It follows, therefore, that the pulmonary artery on the one hand, and the aorta on the other, form two half-rings, like the branches of the letter x, which embrace each other by their concavities. The pericardiac portion of the aorta is situated beneath the sternum, from which it is separated by the pericardium and the anterior mediastinum.

The second portion, comprising the horizontal and descending portions of the arch. On the outside of the pericardium, the aorta is in relation *in front and on the left side* with the left pleura, and is separated by it from the corresponding lung, which is excavated at that point. The phrenic and pneumogastric nerves are also in immediate contact with it. *Behind, and on the right side* (*f*, *fig.* 171.), it is in direct relation with the trachea, the commencement of the left bronchus, the œsophagus, the thoracic duct, the recurrent nerve, the vertebral column, and a great number of lymphatic glands.

By its convexity, which is directed upwards, it gives origin to three large arterial trunks, viz. proceeding from the right to the left side, the *brachio-cephalic* (*e*, *fig.* 198.) or *innominate*, the *left common carotid* (*f*), and the *left subclavian* (*g*) arteries. The highest point of the arch is opposite the origin of the brachio-cephalic artery in the infant, and that of the left subclavian in old subjects. The distance between the fourchette of the sternum, and the highest point of the aortic arch, varies in different ages and individuals: it is generally from ten to twelve lines in the adult; it is much less in the aged and

* The limits of the arch of the aorta are not well defined; most authors exclude the first curve of the artery. The lower boundary is marked by the origin of the left subclavian, according to some; by the left bronchus, according to others; and, lastly, according to a great many, by the articulation of the fourth with the fifth dorsal vertebra.

in the new-born infant, but for very different reasons; in the infant it is owing to the undeveloped condition of the sternum, but in advanced age it depends upon dilatation of the arch of the aorta; in some adults also we find the distance very inconsiderable, and this is important in reference to the operation of tracheotomy.

By its *concavity*, which is directed downwards, the arch of the aorta is in relation with the left recurrent nerve, which embraces it as it were in a loop, having its concavity turned upwards; with the left bronchus (*p*, *fig.* 171., also *fig.* 198.), which is placed behind the horizontal portion of the arch, and then becomes situated in front of its descending portions, so that the aorta during its curvature has two different relations with this air tube; and lastly with a very great number of lymphatic glands, which in some measure fill up the concavity of the aortic arch.

Anomalies of the arch of the aorta. A very remarkable anomaly of the arch of the aorta has been observed, in which the vessel, being simple at its origin, divides into two trunks, which pass one in front, and the other behind the trachea, and then re-unite to form the descending aorta. The aorta sometimes presents traces of a subdivision into two from its origin; such a case appears to indicate a fusion of two aortæ into one, for we then find five sigmoid valves.

The Thoracic Aorta.

The *thoracic aorta* (*b c*, *fig.* 198.) is situated in the posterior mediastinum along the left side of the vertebral column, and it projects into, and encroaches upon, the left cavity of the chest.

Relations. It corresponds on the *left side* with the lung, from which it is separated by the left wall of the posterior mediastinum; *on the right*, it is in relation with the œsophagus, the vena azygos, and the thoracic duct; *in front*, with the left pulmonary arteries and veins above; with the œsophagus (*h*) below, which canal becomes anterior to it before passing through the œsophageal opening in the diaphragm, and with the pericardium in the middle, by which it is separated from the posterior surface of the heart; *behind*, it is in relation with the vertebral column, the thoracic duct passing between them above.

The thoracic aorta is surrounded by an abundance of cellular tissue, and by a number of lymphatic glands.

Diaphragmatic portion of the thoracic aorta. The diaphragm does not form a simple orifice or an aponeurotic arch for the aorta, but its crura (*s s*, *fig.* 199.) are arranged into a muscular semi-canal, from fifteen to eighteen lines in length, and terminating below by a tendinous arch. The aorta is accompanied, whilst passing through this canal, by the thoracic duct and the vena azygos, and it inclines a little to the right side, in order to become anterior to the vertebral column.

The Abdominal Aorta.

The *abdominal aorta* (*c d*, *fig.* 198.) occupies the middle part of the anterior surface of the vertebral column, and is in relation on the *right side* with the vena cava inferior, and *in front* with the pancreas and the third portion of the duodenum, which rests immediately upon it; in the rest of its extent it corresponds with the adherent borders of the mesentery, and with the peritoneum covering the lumbar region of the vertebral column. The stomach and the convolutions of the small intestine separate the aorta from the anterior parietes of the abdomen. When the small intestine falls down into the pelvis, the abdominal aorta may be felt immediately behind the wall of the abdomen, and may be easily compressed there, so as completely to intercept the passage of the blood.*

* This compression is very easily applied in women immediately after parturition, both in consequence of the relaxed state of the abdominal parietes allowing them to be readily depressed, and also from the facility with which the small intestines are moved aside.

COLLATERAL BRANCHES OF THE AORTA.

Enumeration and classification. — *Arteries arising from the aorta at its origin, viz. the coronary or cardiac.* — *Arteries arising from the thoracic aorta, viz. the bronchial, the œsophageal, the intercostal.* — *Arteries arising from the abdominal aorta, viz. the lumbar, the inferior phrenic, the cœliac axis including the coronary of the stomach, the hepatic, and the splenic, the superior mesenteric, the inferior mesenteric, the spermatic, the renal, and the suprarenal or capsular.*

The terminal branches of the aorta consist of the middle sacral and the two common iliac arteries. The *collateral* branches are very numerous: they may be divided into those arising from the pericardiac portion of the aorta, viz. the coronary or cardiac arteries; those arising from the aortic arch, viz. the brachio-cephalic, the left common carotid, and the left subclavian: these we may consider as terminal arteries, which taken together have been termed the ascending aorta in opposition to the descending aorta; those arising from the thoracic aorta, which may be subdivided into the parietal branches, viz. the intercostals, and the visceral, viz. the bronchial, œsophageal, and mediastinal arteries; and lastly, those arising from the abdominal aorta, which may also be distinguished as the parietal, viz. the lumbar and inferior phrenic arteries, and the visceral, viz. the cœliac axis, the superior and inferior mesenteric, the suprarenal, the renal, and the spermatic arteries.

Arteries arising from the Aorta at its Origin.

The Coronary or Cardiac Arteries.

Dissection. Take off the serous membrane from the heart, and also the fat which occupies the furrows; in order to see distinctly the origin of these arteries, remove the pulmonary artery and the infundibulum of the right ventricle.

The *cardiac* or *coronary arteries* (see *figs.* 191, 192.), the nutritious vessels of the heart, or as it were its *vasa vasorum*, are two in number, and are named *right* and *left* on account of their origin, and also anterior and posterior from their distribution. Their number is not constant. Thus the two coronary arteries sometimes arise by a common trunk, to the left of the pulmonary artery.* Sometimes there are three coronary arteries; Meckel has seen four; but these varieties in number do not affect their distribution, for the supernumerary arteries merely represent branches, which, instead of arising from the coronary arteries themselves, proceed directly from the aorta.

Origin. They arise from the anterior part of the circumference of the aorta, immediately above the free margin of the sigmoid valves, at the highest points of the two corresponding sinuses. The origins of these vessels are so situated, that their orifices are not covered by the valves when these latter are applied to the walls of the aorta, so that the heart receives its arterial blood at the same time as all the other organs. The angle at which the coronary arteries arise is extremely obtuse, so that the course of the blood in them is completely retrograde.

The coronary arteries differ from each other in caliber, the right being larger than the left, and also in their course, so that a special description is requisite for each.

The *left* or *anterior coronary artery* is destined principally for the anterior furrow of the heart; it is concealed at its origin by the infundibulum, from between which and the left auricula it then escapes, and entering (*e*, *fig.* 191.) the anterior furrow of the heart, traverses it in a very tortuous manner,

* The coronary arteries were denominated by the older anatomists, and especially by Bartholin, *coronariæ modo simplex, modo gemina.*

and anastomoses at the apex with the right or posterior coronary artery. Not unfrequently this artery divides into two branches, one of which runs along the anterior furrow, while the other passes upon the anterior surface of the left ventricle. In this course, opposite the base of the ventricles, the artery gives off an auriculo-ventricular branch, which, arising at a right angle, enters the left auriculo-ventricular furrow, and passing along it turns round the base of the left ventricle, as far as the posterior inter-ventricular furrow (*e*, *fig.* 192.), where it anastomoses with the right coronary artery.

The *right* or *posterior coronary artery* is larger than the left; it arises to the right of the infundibulum, between that part and the right auricle. Immediately after its origin it is surrounded with a large quantity of fat, and turns directly, so as to gain the right auriculo-ventricular furrow. At the upper end of the posterior interventricular furrow (*e*, *fig.* 192.) it bends at a right angle, and entering the furrow, runs along it to the apex of the heart, where it anastomoses with the left coronary artery. At the point where it changes its direction, the right coronary artery gives off a branch, which anastomoses with the auriculo-ventricular branch of the left artery.

From this description it follows, that the cardiac arteries and their principal divisions occupy the furrows of the heart: that they form two vascular circles, which are placed at right angles to each other like the furrows themselves; that the auriculo-ventricular circle is formed on the right by the trunk of the right cardiac, and on the left by a branch of the left cardiac artery; that the vessels forming these two circles are tortuous, but especially those on the ventricles, because that part of the heart is subject to greater variations in its dimensions than the part with which the auriculo-ventricular circle is in relation; and lastly, that both coronary arteries anastomose by inosculation, and therefore can easily supply each other.

All the arteries of the heart proceed from these two circles. The *auriculo-ventricular circle* gives off some ascending or *auricular* branches, an aortico-pulmonary branch to the origins of the aorta and pulmonary artery, and an adipose branch, all of which were pointed out by Vieussens; also some descending or ventricular branches, the two principal of which run somewhat obliquely along the right and left borders of the heart.

The *ventricular circle* gives off branches which penetrate the fleshy fibres at right angles. A large artery, which has been described as the *artery of the septum*, appears to be one of the terminal branches of the left coronary artery; it dips into and is lost in the substance of the septum.

Lastly, the coronary arteries communicate with the bronchial. They are very liable to calcareous deposits.

Arteries arising from the Thoracic Aorta.

These may be divided into visceral branches, all of which arise from the front of the aorta, viz. the *bronchial* and the *œsophageal*, and parietal branches, which arise from the back of the aorta, viz. the *aortic intercostals.*

The Bronchial Arteries.

Dissection. Carefully take away the heart and pericardium, dissect the bronchi, and trace these arteries both to their origin and towards their termination.

Number and origin. The bronchial arteries (see *fig.* 198.) vary much both in number and origin. There are generally two on each side; but sometimes there are three or even four arising either at different heights, or by a common trunk. Occasionally, one of them arises from the subclavian, or from the internal mammary, or rather from the first intercostal, or, lastly, from the second, or even the third intercostal artery.

I have seen the inferior thyroid artery give off a bronchial artery, which,

after running along the trachea, passed in front of the right bronchus, and anastomosed freely with the right bronchial furnished by the aorta. The right bronchial artery is always larger than the left.

Whatever be their origin, the bronchial arteries pursue a tortuous course to the corresponding bronchus, and are usually situated on its posterior surface. When the right bronchial artery arises from the aorta, it crosses obliquely over the lower part of the trachea. The bronchial arteries always give some branches to the œsophagus; a very great number to the bronchial glands: also several to the left auricle: they anastomose with the coronary arteries on the one hand, and with the inferior thyroid and the superior intercostal arteries on the other.

Haller believes that the terminations of the bronchial arteries anastomose with the divisions of the pulmonary artery, and says that he has seen free and evident communications between them.*

The Œsophageal Arteries.

The *œsophageal arteries* (*h*, *fig.* 198.) vary in number from three to seven, and are remarkable for their slenderness and length. They arise in succession from the front of the aorta, which they leave at right angles, and immediately curve downwards to reach the front of the œsophagus, where they divide into extremely slender ascending, and into very long descending branches, from which are given off a numerous series of twigs. The superior œsophageal artery almost always anastomoses with the bronchial arteries, and the œsophageal branches of the inferior thyroid. The inferior œsophageal artery anastomoses with the œsophageal branches derived from the left inferior phrenic and from the coronary artery of the stomach.

The branches from the œsophageal arteries perforate the muscular coat of the œsophagus, ramify in the submucous cellular tissue, and terminate in a network in the substance of the mucous membrane.

The Aortic Intercostal Arteries.

Dissection. In order to see the posterior branches, dissect the posterior spinal muscles, and open the vertebral canal. To see the anterior branches or the intercostals, properly so called, expose these vessels on the inside of the parietes of the chest in the first half of their course, and then on the outside of the chest to their termination.

The *aortic* or *inferior intercostals* (*i i i′ i′*, *fig.* 198.) so named to distinguish them from the superior intercostal, a branch of the subclavian, and from the anterior intercostals, derived from the internal mammary, are generally eight or nine in number, the upper two or three intercostal spaces being supplied by the superior intercostal branch of the subclavian.

The varieties in their number depend upon the number of intercostal spaces which are supplied with branches from the subclavian, and also upon the number of intercostal arteries which arise by a common trunk.

Origin. They arise at various angles from the back of the aorta; the superior generally at an obtuse angle to gain the spaces situated above them; the succeeding ones at different angles, which are less and less obtuse, and sometimes right angles or even acute angles. In the latter case the vessel immediately ascends to reach the intercostal space for which it is intended. The right and left intercostals are of equal size; and there is little difference in this respect between the superior and the inferior intercostals.

In consequence of the aorta being situated towards the left side, the right intercostals (*i′ i′*) are longer than the left. They turn over the body of each dorsal vertebra, passing behind the œsophagus, the thoracic duct, and the

* See note, p. 560.

vena azygos, and reach the corresponding intercostal space. The left intercostals enter their proper spaces at once. Both are in relation with the costal pleura and the thoracic ganglia of the great sympathetic nerve, behind which they are situated. The lower intercostals on the left side are covered by the vena azygos minor. The two lower intercostals on both sides are covered by the pillars of the diaphragm. In their course over the bodies of the vertebræ, the intercostals give off numerous nutritious branches, which enter the foramina on the anterior surface of these bones.

On reaching the intercostal space, each artery immediately divides into an anterior and a posterior branch.

The *anterior* or *intercostal branches* are larger than the posterior, and may be regarded as the continuation of the arteries themselves in their original course. They are at first situated in the middle of the intercostal spaces, between the pleura and external intercostal muscles; they then pass between the external and the internal intercostals, reach the lower border of the rib above them, and are lodged in the grooves found in that situation; having reached the anterior third of the intercostal spaces, where they have become extremely small, they quit the grooves, and again become placed in the middle of the spaces; the superior intercostals then terminate by anastomosing with the intercostal branches of the internal mammary, and the inferior intercostals with the epigastric, the phrenic, the lumbar, and the circumflex iliac arteries.

During its whole course, each intercostal branch is in relation with the corresponding intercostal vein and nerve. The inferior intercostal arteries, commencing at the fifth, after leaving the intercostal spaces, are lost in the external and internal oblique muscles of the abdomen, which, as we have seen, form, as it were, continuations of the intercostal muscles (see MYOLOGY).

The intercostal branch furnishes numerous ramusculi to the intercostal muscles, the ribs, the sub-pleural cellular tissue, the muscles which cover the thorax, and even to the integuments. A very small, but tolerably constant branch is given off at an acute angle from the artery, at the moment where it dips between the two sets of intercostals, gains the upper border of the rib below, and is lost in the periosteum and the muscles, after running a variable distance.

The *posterior* or *dorsi-spinal branches* pass directly backwards between the transverse processes of the vertebræ, on the inner side of the superior costo-transverse ligaments, and each of them immediately divides into two branches; one, the *spinal*, which enters the inter-vertebral foramen, and again divides into a *vertebral* branch for the bodies of the vertebræ, and a *medullary* branch for the coverings of the spinal cord, and for the cord itself, to the distribution of which we shall hereafter return. The second, or *dorsal* branch, is larger than the spinal, and forms a continuation of the dorso-spinal trunk; it escapes behind between the transverso-spinalis and longissimus dorsi, sends some ramifications between the longissimus dorsi and sacro-lumbalis, and terminates in the muscles and the skin.

ARTERIES ARISING FROM THE ABDOMINAL AORTA.

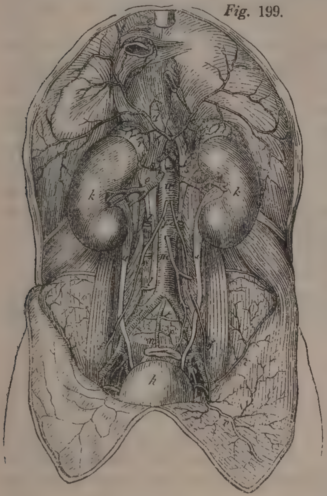
The branches furnished by the abdominal aorta are parietal, viz. the *lumbar* and the *inferior phrenic* arteries; and the visceral branches, viz. the *cœliac axis*, the *superior and inferior mesenteric*, the *spermatic*, the *renal*, and the *middle suprarenal* arteries. In reference to their place of origin, these arteries may be divided into those which arise from the anterior aspect of the aorta, viz. the cœliac axis, the superior and inferior mesenteric, and the spermatic arteries; and those which arise from its sides, viz. the renal, the middle suprarenal, and the lumbar arteries. The lumbar arteries might be regarded as arising from the back of the aorta.

The Lumbar Arteries.

Dissection. Remove the pillars of the diaphragm and the psoas muscles. In order to expose the dorsi-spinal branches, dissect the posterior spinal muscles, and open the vertebral canal. To expose the anterior branches, dissect the abdominal muscles carefully.

The *lumbar arteries* (*l l*, *fig.* 199.) continue the series of intercostals, with which they present numerous analogies in reference to their origin, course, and termination. They vary in number from three to five, but there are usually four. These varieties depend either upon the greater or less size of the ilio-lumbar artery, which bears the same relation to the lumbar arteries as the superior intercostal does to the aortic intercostals, and which sometimes takes the place of the last, sometimes of the last two lumbar arteries; or the varieties may depend on several lumbar arteries arising from a common trunk.

Fig. 199.



Origin. The lumbar arteries are given off at right angles from the back of the aorta. Very rarely the right lumbar arteries arise by a common trunk with the left.

Course. They proceed transversely in the grooves on the bodies of the vertebræ, and pass under the tendinous arches of the psoas, by which muscle they are covered. They send a great number of branches to the bodies of the vertebræ; and having reached the base of the transverse processes, each of them divides into two branches, a *posterior* or *dorsi-spinal*, and an *anterior* or *abdominal*, branch.

The *posterior branch*, which is analogous to the dorsi-spinal of an intercostal artery, divides into two branches: one, the *spinal*, which enters the spinal canal through the intervertebral foramen, and subdivides into a *vertebral* branch for the body of the vertebra, and a *medullary* branch for the cord and its coverings; the other branch is the dorsal, which terminates in the muscles and integuments of the lumbar region.

The *anterior branch* is smaller, and analogous to the anterior branch of an intercostal artery: it is situated between the quadratus lumborum and the middle layer of the aponeurosis of the transversalis, and ramifies in the substance of the abdominal muscles. The anterior branch of the first lumbar artery runs along the lower border of the twelfth rib, passes obliquely downwards and forwards, and divides into two ramusculi, one of which continues in the same course, while the other turns downwards to the crest of the ilium. The anterior branches of the second and third pair of lumbar arteries are generally small: not unfrequently the third artery is wanting. The anterior branch of the fourth lumbar artery runs along the crest of the ilium, and sends branches to the muscles of the abdomen and to the iliacus and glutæi muscles.

The Inferior Phrenic Arteries.

Dissection. Carefully detach the peritoneum from the lower surface of the diaphragm.

The *inferior phrenic* or *diaphragmatic*, or the *sub-diaphragmatic arteries* (*d d*, *fig*. 199.), so named in contradistinction to the superior phrenic, which are branches of the internal mammary, are so frequently derived from the cœliac axis, that some anatomists, Meckel among others, describe them as branches of that trunk. They are two in number, a *right* and a *left*. They arise from the aorta, immediately below the cordiform tendon of the diaphragm, either side by side, or by a common trunk. Sometimes they arise from the cœliac axis itself, or rather from the coronary artery of the stomach, from the renal, or from the first lumbar artery; in some subjects we find as many as three or four.

Each artery passes upwards and outwards in front of the corresponding pillar of the diaphragm, gives some twigs to this pillar, and one to the supra-renal capsule, and then divides into two branches, an *internal* and an *external*. The *internal* branch passes directly forwards, ramifies and anastomoses by loops with the vessel of the opposite side around the œsophageal opening, behind the cordiform tendon of the diaphragm. The *external* branch is larger and more tortuous than the preceding; it proceeds obliquely outwards, between the peritoneum and the diaphragm, and divides into a great number of branches, which extend as far as the attachments of this muscle, where they anastomose with the intercostal and the internal mammary arteries.

The right inferior phrenic artery, moreover, sends some branches into the coronary ligament of the liver; the left artery gives off a branch to the œsophagus, which enters through the œsophageal opening in the diaphragm, and joins the œsophageal branches derived from the coronary artery of the stomach and from the aorta.

The Cœliac Axis.

Dissection. Elevate the liver by means of hooks, or by a ligature fixed to the right side of the chest; depress the stomach; divide the fold of peritoneum by which these two viscera are united; and search for the cœliac axis between the pillars of the diaphragm, by removing the solar plexus of nerves, which forms a thick layer in front of it.

The *cœliac axis* or *artery* (from κοιλία, the belly or stomach; *y*, *fig*. 199.), le tronc opisthogastrique, *Chauss*. (ὄπισθεν, behind, γαστὴρ, the stomach), supplies the stomach, the liver, the spleen, the pancreas, and the great omentum. It is remarkable for its size, being larger than any of the other branches of the abdominal aorta, not excepting the superior mesenteric; for arising at a right angle from the front of the aorta, immediately below the phrenic arteries; for its horizontal course, which is rarely more than five or six lines in extent, and for its very early division into three branches, *ad modum tridentis*. These three branches are of unequal size: they are the *coronary artery of the stomach* (*b*, *fig*. 200.), the *hepatic* (*c*), and the *splenic* (*d*), which together are called the *cœliac tripos*, or the *tripos of Haller*.

In its short course the cœliac axis is in relation with the lesser curvature of the stomach, or rather with the gastro-hepatic omentum, behind which it is situated; on the left side, it is in relation with the cardia; below, with the upper border of the pancreas, upon which it rests; above, with the left side of the lobulus Spigelii. It is surrounded by so large a plexus of nerves, that it cannot be exposed until the plexus is removed.

The Coronary Artery of the Stomach.

The *coronary artery of the stomach*, or the *superior gastric* (*b*, *figs*. 200, 201.), is the smallest branch of the cœliac axis. It is directed upwards and to the left side, to reach the œsophageal orifice of the stomach; it then turns suddenly to the right side, pursues a semicircular course along the lesser curvature

(*arteria coronaria ventriculi*), and terminates by inosculating with the pyloric artery (*e*), a branch from the hepatic.

In this course it gives off from its convex border *ascending œsophageal branches*, which pass through the œsophageal opening of the diaphragm, ascend upon the œsophagus, and are there distributed like the aortic œsophageal branches, with which they anastomose; also *cardiac branches*, which form a vascular network around the œsophageal opening of the stomach, and pass transversely upon its great tuberosity; and a series of *gastric branches*, which arise along the lesser curvature, and are divided into two sets, an anterior set for the front, and a posterior set for the back of the stomach. No branch arises from the concavity of the curve formed by this artery.

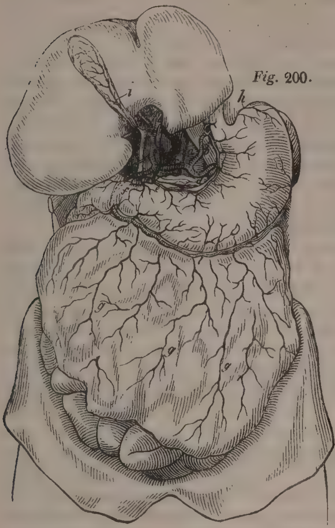


Fig. 200.

Not unfrequently the coronary artery of the stomach gives off an hepatic branch, and hence the first branch of the cœliac axis has been called the *gastro-hepatic* by some anatomists. In such cases, as may be conceived, this artery is very large. It is also not uncommon to find the left inferior phrenic arising from it.

The Hepatic Artery.

The *hepatic artery* (*c*, *figs.* 200, 201.) is larger than the preceding. It passes transversely from the left to the right side, describing a curve, having its concavity directed upwards, and moulded, as it were, upon the lobulus Spigelii. Near the pylorus it changes its direction, and passes upwards to the transverse fissure of the liver, where it divides into two branches. In the latter part of its course it is contained within the gastro-hepatic omentum, in front of the foramen of Winslow, and is in relation with the ductus choledochus and the vena portæ, the vein being placed behind both the artery and duct.

It is not uncommon to find two hepatic arteries, one derived from the coronary of the stomach, and the other from the superior mesenteric. Sometimes there are even three hepatic arteries, one from the coronary of the stomach, a second from the superior mesenteric, and a third from the cœliac axis.

Collateral branches. The hepatic artery gives off three collateral branches, the *pyloric*, the *right gastro-epiploic*, and the *cystic*.

The *pyloric* artery (*e*) is a small vessel which arises from the hepatic, near the pylorus: it runs from right to left along the pylorus and the lesser curvature of the stomach, and inosculates with the coronary artery (*b*) of that viscus. Two sets of branches, an anterior and a posterior, arise from its convex border, and are distributed to the stomach and the first part of the duodenum, in the same manner as those from the coronaria ventriculi itself. Not unfrequently the pyloric artery terminates near the pylorus, without anastomosing with the coronary.

The *right gastro-epiploic* artery (*f*, *figs.* 200, 201.) is remarkable for its

size and for its length. It passes vertically downwards, behind the first portion of the duodenum near the pylorus. Having reached below the duodenum, it changes its direction, passes from right to left (*l*) along the great curvature of the stomach, where it inosculates with the left gastro-epiploic (*h, fig.* 201.). In one case, where the hepatic artery was given off by the superior mesenteric, the right gastro-epiploic arose directly from the cœliac axis.

The first portion of this vessel, usually called the *gastro-duodenal* artery, furnishes several branches to the pylorus, which may be called the *inferior pyloric*; it then gives a branch to the duodenum and the head of the pancreas, named the *pancreatico-duodenalis* (*k*), and remarkable for its anastomosing with the superior mesenteric; an arrangement that leads, as it were, to the cases in which the hepatic itself is derived from the last mentioned artery; it is also remarkable for its size, which is sometimes such that the continuation of the vessel, the right gastro-epiploic artery proper, is only half the size of the trunk from which it is given off (the gastro-duodenal).

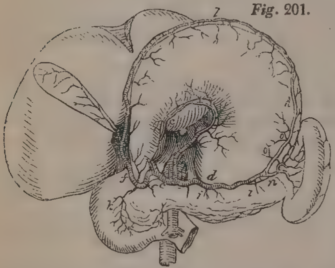
In its horizontal portion along the great curvature of the stomach, the right gastro-epiploic sends both ascending and descending branches: the former, or *gastric* branches, divide into two sets; one for the anterior, and one for the posterior surface of the stomach. The latter, or *epiploic* branches (*g g, fig.* 200.), are extremely long and slender; they pass downwards parallel to each other, without any windings, in the substance of the two anterior layers of the great omentum, are reflected upwards at its lower border, just as the two layers are themselves, and accompany them as far as the transverse colon, to which they are distributed.

The *cystic* artery (*i, fig.* 200.) is a small vessel which almost always arises from the right of the terminal divisions of the hepatic artery, reaches the neck of the gall bladder, and divides into two branches; one superior, running between the liver and the vesicula, the other inferior, which pursues a tortuous course between the peritoneum and the proper coat of the gall bladder, divides and subdivides, and is finally distributed to the mucous membrane.

Terminal branches. Of the two terminal branches of the hepatic artery, one dips into the right extremity of the transverse fissure of the liver, and the other into the left extremity of the same fissure: in these situations they become applied to the corresponding branches of the vena portæ and hepatic duct, are inclosed with them in the capsule of Glisson, and closely accompany the corresponding ramifications of those vessels through all their divisions and subdivisions.

The Splenic Artery.

Fig. 201.



The *splenic artery* (*d, figs.* 200, 201.) is larger than either of the other divisions of the cœliac axis. Immediately after its origin it is received into a slight groove, formed along the whole of the upper border of the pancreas (*i*). It passes from the right to the left side, and is exceedingly tortuous in its course*: having reached the hilus of the spleen, it divides into a great number, of terminal branches (*n, fig.* 201.), which enter that organ separately. It is not rare to find one of these branches detached from the others, to be distributed either to the upper or the lower end of the spleen.

Near the spleen, the splenic artery and its divisions are inclosed within the gastro-splenic omentum.

* I have seen some splenic arteries not at all tortuous; and at other times I have found the curvatures so decided, that the lower part only of the curves came in contact with the pancreas.

The relations of the splenic artery to the posterior surface of the stomach explain how, in certain cases of ulceration of the stomach opposite the pancreas, this artery may become the source of hæmatemesis.

The splenic artery gives off several collateral branches : —

The *pancreatic* arteries (*i i*), which are variable in number, and are very large, considering the size of the organ to which they are distributed.

The *left gastro-epiploic artery* (*h*), which often arises from one of the divisions of the splenic, passes vertically downwards, behind the great end of the stomach, gains the great curvature, along which it runs from left to right, and anastomoses with a branch of the hepatic, viz. the right gastro-epiploic (*l*); like which artery it sends off *ascending* or *gastric*, and *descending* or *epiploic* branches. The size of the gastro-epiploica sinistra varies much, and has an inverse proportion to that of the gastro-epiploica dextra.

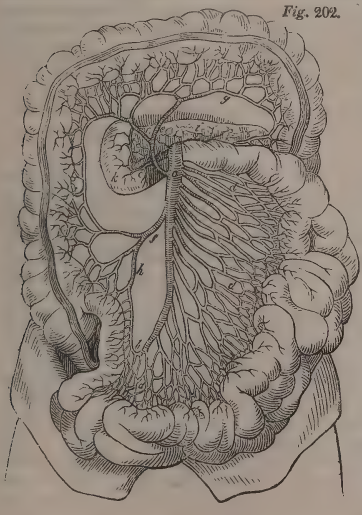
The *vasa brevia* (*o o*), which are remarkable for their number and shortness, generally arise from one or several of the terminal branches of the splenic artery, just as these are entering the spleen; they pass directly, by a retrograde course, from that organ to the great cul-de-sac of the stomach, as far as the cardia, where they anastomose with the cardiac branches of the coronary artery of the stomach.

From the preceding description of the branches of the cœliac axis, we perceive that the stomach is surrounded by an uninterrupted arterial circle, formed by the right and left gastro-epiploic, by the pyloric, and by the coronary arteries; and that, secondly, the branches derived from this circle constitute an anastomotic network upon the anterior and posterior surfaces of the stomach.

The Superior Mesenteric Artery.

Dissection. Look for the origin of the artery between the pancreas and the third portion of the duodenum; turn the whole of the small intestines to the left side; remove with care the right layer of the mesentery, the left layer of the right lumbar mesocolon, the inferior layer of the transverse mesocolon, and the numerous lymphatic glands which conceal the artery and its divisions.

Fig. 202.



The *superior mesenteric artery* (below *y*, *fig.* 199.) is the artery of the small intestine, and of the right half of the large intestine. It arises from the front of the aorta, immediately below the cœliac axis, and very rarely from a common trunk with it. It is at first situated behind the pancreas, and then passes vertically downwards, between that gland and the third portion of the duodenum, which is crossed at right angles by it, and of which it forms the lower boundary (*vide* DUODENUM); it at length reaches the mesentery, opposite the point (*a*, *fig.* 202.) where that fold meets the transverse mesocolon. Continuing

Why do these curvatures exist? It cannot be to accommodate the variations in the size of the spleen; but is it to retard the flow of the blood? There is no proof of it; indeed, the law which governs the existence of a tortuous condition of certain arteries is yet to be discovered.

its course within the substance of the mesentery, and following its adherent border, it describes a slight curve, with the convexity directed to the left, and the concavity to the right side: gradually diminishing in size as it advances, it proceeds to opposite the ileo-cæcal valve (*b*), and then becomes so small, that it can no longer be distinguished from the branches given off from it. It follows, therefore, that the trunk (*a b*) of the superior mesenteric artery corresponds with the adherent border of the mesentery, with the length of which it, as it were, agrees.

Collateral branches. Whilst behind the pancreas, the superior mesenteric sends off *pancreatic branches* (*k*), which anastomose with those derived from the hepatic and the splenic arteries; it rather frequently gives off the hepatic, and it is then larger than the cœliac axis.

In the mesentery, the superior mesenteric gives off two sets of branches; one set arising from its convexity, and forming the *arteries of the small intestine*, the other set from its concavity, viz. *the arteries of the great intestine*, called the right *colic* arteries.

The arteries of the small intestine have received no particular name; they are large branches, directed obliquely downwards and forwards, all of which proceed parallel to each other in the substance of the mesentery, towards the concave border of the small intestine. Their number is irregular, and their size unequal: seven or eight of them are at least equal in size to the radial artery, others are smaller; the superior branches are generally the largest. Their number is calculated at from fifteen to twenty.

After a course of about two or three inches, each of them bifurcates; the branches of the bifurcation separate from each other, and curving into arches, inosculate with the neighbouring branches. From the convexity of this series of arches, which is turned towards the intestine, a multitude of branches arise, which soon bifurcate, and form anastomotic arches (*d d d*), which, as they are nearer the small intestine, describe a curve of much greater extent in the mesentery than the first series. From the convexity of this second series of arches a great many more branches arise than were given off from the first series. Lastly, from the division of these branches a third series of anastomotic arches is formed, which is still nearer the concave border of the intestine than the second.

There are only three series of arches at the commencement and the termination of the small intestine, but in the middle there is a fourth, sometimes even a fifth.

From the convexity of the arches nearest to the small intestine arise two sets of vessels, intended for the two halves of the cylindrical gut. Each of these sets of vessels divides into *superficial branches*, which, ramifying beneath the peritoneum, form a superficial network, and anastomose upon the convex border of the intestine; and into *deep branches*, which perforate in succession the muscular and cellular coats, and terminate in an inextricable network in the mucous membrane.

The series of anastomotic arches formed by the divisions of the superior mesenteric artery, not only regulate the current of the blood, but also enable a small number of branches, occupying a very limited space at the root of the mesentery, to supply branches to so great an extent of surface as the entire length of the small intestine, which is from fifteen to twenty-one feet. This spreading out of the vessels over a large surface will be still better seen in the arrangement of the arteries of the great intestine.

The arteries for the great intestine, or the *right colic arteries*, are two or three in number, and are distinguished into the superior (*e*), middle (*f*), and inferior (*h*). They arise from the concavity of the curve formed by the superior mesenteric artery; and pass from the mesentery, in which they are inclosed at their origin, into the right lumbar mesocolon. The superior is ascending, the middle horizontal, and the inferior descending; near the great intestine they bifurcate. The branches of the bifurcation anastomose, and form very large

arches, with their convexities turned towards the great intestine. From these arches the intestinal branches take their origin directly, and divide into two sets of parallel ramifications, an anterior and a posterior, which, like those of the small intestine, subdivide into the *sub-peritoneal* and the *deep branches*, and terminate in the different coats of the intestine. Where the primary anastomotic arches are situated at a certain distance from the intestine, for example opposite the angles of bifurcation of the arteries, or opposite the angles formed by the ileum with the cæcum, and by the ascending with the transverse colon, we find one, or even two, small arches filling up the angular interval.

The upper branch (*g*) of the right superior colic artery (*e*, *figs.* 202, 203.), which supplies the right half of the arch of the colon, anastomoses with the upper branch of the left colic artery (*f*, *fig.* 203.), which is derived from the inferior mesenteric (*c*). This remarkable anastomosis between the superior and inferior mesenteric arteries has been pointed out by anatomists as the most important anastomosis in the body.

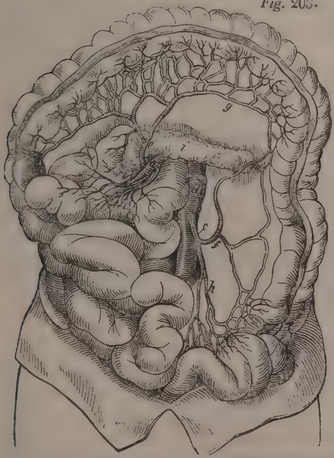
The lowest branch of the right inferior colic artery (*h*, *fig.* 202.) anastomoses with the termination (*b*) of the superior mesenteric, which becomes exceedingly slender. This right inferior colic, or *ileo-colic* artery (*h*), supplies the cæcum, the ileo-cæcal angle, and the appendix vermiformis.

The omphalo-mesenteric artery. In the early periods of intra-uterine life, the superior mesenteric artery gives off a branch, called the *omphalo-mesenteric*, which reaches the umbilicus, passes out of the abdomen, traverses the entire length of the cord, and is distributed upon the umbilical vesicle. I have found this artery perfectly distinct in an anencephalous fœtus at the full term; it is generally obliterated towards the end of the second month of intra-uterine life.

The Inferior Mesenteric Artery.

Dissection. Turn the small intestines to the right side; spread out the arch of the colon, the right lumbar colon, and the sigmoid flexure; remove the peritoneum, which forms the inferior layer of the transverse mesocolon, and the right layer belonging to the descending colon and sigmoid flexure.

Fig. 203.



The *inferior mesenteric artery* (*m*, *fig.* 199.; *c*, *fig.* 203.) is much smaller than the superior. It arises from the front of the aorta, about two inches above the bifurcation of that vessel. It descends vertically in front of and in contact with the aorta, and then in front of the left common iliac artery. It is at first inclosed in the iliac mesocolon, but afterwards enters the mesorectum, where it divides into two branches, which are named the *superior hæmorrhoidal* (*h*, *fig.* 203.). In this course the inferior mesenteric gives off no branch on the right side; on the left it gives two, more frequently three branches, called the *left colic* arteries (*f*), which are distributed in precisely the same manner as the right colic arteries. I have already said, that the upper division of the left superior colic artery (*f*) inosculates with the upper division (*g*) of the right superior colic (*e*). Near the sigmoid flexure we find two, and sometimes three series of arches from the *sigmoid* branch, so arranged that the last may reach the intestine.

The superior hæmorrhoidal arteries are distributed to the rectum, in the same manner as the other intestinal arteries; near the sphincter, they anastomose with the middle hæmorrhoidals, which are derived from the internal iliac arteries.

The Spermatic Arteries.

The *spermatic arteries* (*o o*, *fig.* 198.; *f f*, *fig.* 199.) are distributed to the testicles, in the male; and to the ovaries, in the female.

They are two in number, and are as variable in their origin as they are regular in their course and distribution.

Their *origin* is remarkably distant from their termination; an unsatisfactory attempt has been made to explain this circumstance by referring to the situation of the testicle in the fœtus.

Varieties of origin. These arteries generally arise from the front, sometimes from the side of the aorta, below the corresponding renal artery, rarely above it, and still more rarely from the renal itself. It is rather rare for the right and left spermatics to come off at the same heights. I have seen the right spermatic artery arise below the renal, and the left by the side of the inferior mesenteric.

Whatever may be their origin, these arteries pass directly downwards. Sometimes they come off at a right angle, and then curve downwards, so as to descend almost vertically upon the sides of the spine, behind the peritoneum, in front of the corresponding psoas muscle and ureter, and on the inner side of the spermatic veins. The right spermatic artery is in relation with the vena cava inferior, and almost always passes in front, but sometimes behind it; the artery of the left side is situated behind the sigmoid flexure of the colon. On both sides, having reached the side of the pelvis, the artery is situated on the inner side of the psoas, in front of the external iliac artery, and is then differently distributed in the two sexes.

In the male (*f*, *fig.* 199.), it enters the abdominal orifice of the inguinal canal, along which it proceeds, and together with the vas deferens and the spermatic veins, forms the spermatic cord; it escapes from the canal, and at a greater or less distance from the ring, divides into two branches, one of which enters the head of the epididymis, whilst the other, the *testicular*, penetrates the testicle at its upper border, and is then distributed as already described. (See TESTICLES.)

In the female, the ovarian arteries (*o o*, *fig* 198.), which are much shorter than the spermatics of the male, dip into the pelvis, reach the upper border of the ovaries, supply them and also the Fallopian tubes with a great number of branches, and terminate upon the sides of the uterus, by anastomosing freely with the uterine arteries (*n n′*).

The ovarian arteries are distributed more to the uterus than to the ovary, as may be proved by the post mortem examination of the body of a pregnant or puerperal female; for it is then seen that the ovarian arteries also become largely developed as well the uterine, and that the branches sent to the uterus are enormous in comparison with those given off to the ovaries.

The ovarian arteries are very tortuous, especially opposite the brim of the pelvis; they are quite as much convoluted as the uterine arteries.

The Renal or Emulgent Arteries.

The *renal* or *emulgent arteries* (*e e*, *fig.* 199.) arise at right angles from the side of the aorta, above the inferior mesenteric: the left renal artery often arises a little higher than the right, doubtless on account of the size of the liver. These arteries are very large in comparison to the kidney, for they are nearly equal in size to the cœliac axis, or the superior mesenteric; they are remarkable for their transverse and generally straight direction; for their shortness; and, lastly, for their numerous varieties. These we shall now mention.

Varieties as to number. There is generally one for each kidney, but frequently there are two, three, or four. *Varieties as to origin.* Not uncommonly, the renal arteries arise from the aorta lower down than usual, or even from the common iliac or the internal iliac. The two latter modes of origin are scarcely observed, excepting when the kidney is displaced, and occupies either the iliac fossa or the cavity of the pelvis. In a case which I recently examined, the kidney occupied the cavity of the pelvis, and there were two renal arteries, one of which arose from the aorta at its bifurcation, and the other near the inferior mesenteric. Lastly, I should add that Meckel has seen the two renal arteries arise by a common trunk from the front of the aorta. *Varieties in direction.* When two renal arteries arise from the same side, or when one divides into two branches, I have found them, in several cases, twisted spirally round each other, like the umbilical arteries. *Varieties as to division.* The renal artery sometimes divides immediately after its origin; and then one of the branches, separating itself from the others, proceeds to one or other extremity of the kidney. Such a mode of division leads to those cases in which there is more than one artery.

Relations. The renal arteries are covered by the peritoneum and the corresponding renal veins; they are surrounded by a quantity of adipose cellular tissue, and they rest behind upon the bodies of the vertebræ. The right renal artery is also covered by the inferior vena cava. In one case, where there were two renal arteries on the right side, one of these was in front, and the other behind the vena cava.

Collateral branches. The renal arteries give off some small twigs to the suprarenal capsules, which are called the *inferior capsular* or suprarenal, and also some small branches to the adipose tissue which covers the kidney, and to its proper cellular coat.

Terminal branches. At the hilus of the kidney, the renal artery divides into three or four branches, all of which enter the hilus, between the pelvis of the ureter, which is behind, and the branches of the renal vein, which are in front. The arteries subdivide in the kidney so as to form a network at the limits between the tubular and cortical substances. (See KIDNEY.) A very few of the branches from this network proceed to the tubular substance, almost all of them being distributed to the cortical substance. Most anatomists have remarked the facility with which even coarse injections pass from the renal arteries into the veins and ureters.

The Middle Suprarenal or Capsular Arteries.

The *middle supra-renal arteries* (*s s*, *fig.* 199.), so named in contradistinction to the superior vessels of the same name, derived from the diaphragmatic, and the inferior, proceeding from the renal, are of large size, in comparison with the organ to which they are distributed. They arise from the sides of the aorta, above the renal, supply twigs to the surrounding fat, and to the pillar of the diaphragm, run along the concave border of the corresponding suprarenal capsule, give off anterior and posterior branches, which enter the furrows on the surface of that organ, and penetrate and ramify in its interior.

ARTERIES ARISING FROM THE ARCH OF THE AORTA.

Enumeration and Varieties.— The Common Carotids.— The External Carotid —the superior thyroid—the facial—the lingual—the occipital—the posterior auricular—the parotid—the ascending pharyngeal—the temporal—the internal maxillary.—The Internal Carotid—the ophthalmic—the cerebral branches of the internal carotid.— Summary of the distribution of the Common Carotids.— Artery of the upper extremity.— The Brachio-cephalic.— The right and left Subclavians—the vertebral and its cerebral branches, with remarks on the arteries of the brain, cerebellum, and medulla—the inferior thyroid —the supra-scapular—the posterior scapular—the internal mammary—the deep cervical—the superior intercostal.— The Axillary—the acromio-thoracic —the long thoracic—the sub-scapular—the posterior circumflex—the anterior circumflex.— The Brachial and its collateral branches.— The Radial, its collateral branches, and the deep palmar arch.— The Ulnar, its collateral branches, and the superficial palmar arch.— General remarks on the arteries of the upper extremity.

Three arterial trunks, intended to supply the head and the upper extremities, take their origin from the arch of the aorta. Proceeding in the order in which they arise, *i. e.* from right to left, they are, the *innominate* or *brachio-cephalic* (*e. fig.* 198.), which soon subdivides into the *right common carotid* (*f*) and *right subclavian* (*g*), the *left common carotid* (*f′*), and the *left subclavian* (*g*).

The direction of that portion of the arch of the aorta which gives origin to these arteries is such, that they are arranged one after the other upon a plane which slopes downwards, backwards, and to the left; so that the trunk of the innominate artery lies almost immediately behind the sternum, while the left subclavian is near the vertebral column.

Varieties. These three arteries present numerous varieties in their origin, all of which appear to me to be referrible to the three following heads:— varieties by approximation or fusion, varieties by multiplication, and varieties by transposition of their origins. In many cases, several of these kinds of varieties may coexist.*

Varieties by approximation or fusion of origins. Sometimes the left common carotid becomes closely approximated to the brachio-cephalic trunk; and this condition leads us to the not very uncommon variety, in which these two vessels arise by a common trunk.† Again, two brachio-cephalic trunks may be given off from the arch of the aorta, one on the right, the other on the left side; the greatest amount of variety of this kind is observed in the case where the three branches which usually arise from the arch are united into one common trunk, which forms an ascending aorta. This arrangement is normal in the ox and some other animals.

Varieties by multiplication of origin. Sometimes the two common carotids arise separately in the interval between a right and a left subclavian, a condition that leads us to the case in which the two carotids arise by a common trunk between the separated subclavians. Again, the left vertebral artery may arise directly from the aorta, between the left carotid and subclavian; this is very common: or the two vertebrals, the two carotids, and the two subclavians may all arise separately; or the inferior thyroid, or the thyroid of Neubauer, from the name of the anatomist who first described this variety, may arise directly from the curvature of the aorta; lastly, the right internal

* [A variety, affecting merely the *situation* of the three primary vessels upon the arch, is noticed by Professor R. Quain (*Opera cit.*). It consists in those vessels arising to the right of their usual position, *i. e.* nearer to the origin of the aorta.]

† [According to the extensive observations of Professor R. Quain, this appears to be by far the most frequent variety.]

mammary and the left vertebral may arise directly from the arch of the aorta.

Varieties by transposition or inversion of origin. The brachio-cephalic trunk is sometimes found on the left side, instead of the right; still more frequently the right subclavian arises separately below the left subclavian, and then passes upwards and to the right side, most commonly behind the trachea and œsophagus, but sometimes between these two canals. Again, the trunks arising from the arch of the aorta have been seen to be given off in the following order: a single trunk for both common carotids; then the left subclavian; and lastly the right subclavian, which arose from behind the arch of the aorta, and passed as in the preceding case.

The Common Carotid Arteries.

Dissection. Dissect the anterior cervical region, preserving all the parts in relation to the vessels. In order to see the thoracic portion of these arteries, remove the upper part of the sternum.

The *primitive*, or *common carotid arteries* (*f f'*, *fig.* 198.; *a*, *fig.* 204.), are the arteries of the head. Their limit above is marked by the upper border of the thyroid cartilage, opposite which they divide into the *external* and *internal* carotids.*

They are two in number, distinguished as the right and left: they differ as to their origin, their length, and their directions; thus—on the left side, the common carotid arises directly from the aorta; on the right, it arises from a trunk common to it and to the subclavian, viz. the *innominate*, or *brachio-cephalic* artery (*e*, *fig.* 198.). As the brachio-cephalic and the left common carotid are given off from the aorta nearly at the same level, it follows that the left common carotid is longer than the right, by the entire length of the brachio-cephalic.

It follows, also, from the obliquity of the arch of the aorta, that the left common carotid is placed much deeper than the right at its origin; but in the cervical region the two carotids are upon the same plane.

They pass somewhat obliquely upwards and outwards immediately after their origin, but they are directed vertically and parallel to each other in the cervical region.† The interval between them is occupied by the trachea and the œsophagus below, and by the larynx and pharynx above. Their course is straight, and without any winding. Their diameter is uniform throughout; a circumstance which is connected with the absence of any collateral branches. The caliber of these arteries is relatively larger in man than in other animals; and this has reference to the greater size of his brain. I have not observed any difference in diameter between the right and left common carotids.

As about one inch in length of the left common carotid lies in the thorax, its relations must be separately studied in that situation.

Relations of the thoracic portion. In front, with the left subclavian vein, and the sterno-hyoid and sterno-thyroid muscles, which separate it from the sternum; *behind*, with the trachea and œsophagus, and with the left subclavian and left vertebral arteries; *on the outside*, with the pleura or the left wall of the mediastinum; *on the inside*, with the brachio-cephalic trunk, from which it is separated by a triangular interval, in which the trachea is visible.

Relations of the cervical portion. These are the same for both arteries. *In front*, each common carotid is covered below by the sterno-mastoid, and more immediately by the sterno-hyoid, sterno-thyroid, and omo-hyoid muscles; the latter of which crosses the artery obliquely.‡ In its upper half it corresponds

* [The common carotid has been seen to divide above the os hyoides, also opposite the thyroid cartilage, and even low down in the neck.]

† [In consequence of the larynx being wider than the trachea, the common carotids are not quite parallel in the neck, but are somewhat further apart above than below.]

‡ In order to omit nothing, I should say that the common carotid is crossed obliquely by a branch which is given off from the superior thyroid artery to the sterno-mastoid muscle.

to the platysma myoides, which separates it from the skin. The cervical fascia, the superior thyroid vein, and the descendens noni, a branch of the hypoglossal nerve, are in more immediate relation with it. The most important of these relations is that with the sterno-mastoid, which, in a surgical point of view, may be regarded as its satellite muscle. *Behind* the common carotid is the vertebral column, from which it is separated by the pre-vertebral muscles, the great sympathetic nerve, and below by the recurrent nerve and inferior thyroid artery. *On the inside* it is in relation with the trachea, œsophagus, larynx, and thyroid gland, which passes in front of the artery when larger than usual; *on the outside* of the artery is the internal jugular vein. The pneumogastric nerve lies at the back, between the artery and vein. The common carotids are also surrounded by much loose cellular tissue, and by some lymphatic glands.

The left common carotid is in more direct relation with the œsophagus than the artery of the right side.

The common carotids give off no branch during their course: nevertheless, it is not very rare for this artery to give off the inferior thyroid artery, or a supernumerary branch, known as the *middle thyroid.* Neubauer has seen the common carotid give off a thyroid artery, and the internal mammary of the right side.

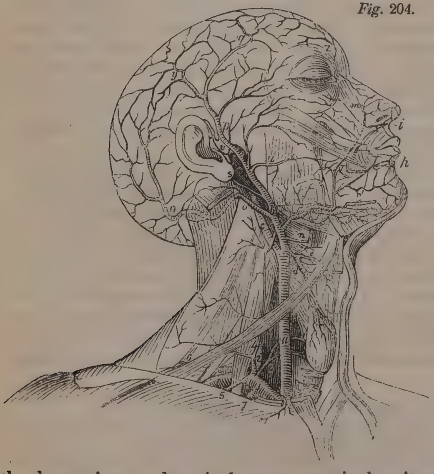
Terminal branches. Having reached the upper border of the thyroid cartilage, at a variable height, according to the subject, the common carotid divides into two branches, called the *external* and *internal carotids*, which, by no means a common arrangement, do not leave each other at an acute angle, but remain in contact, and even frequently become crossed before they separate. The point of division is also remarkable for a sort of ampulla or dilatation.

The External Carotid Artery.

Dissection. Prolong the incision made for exposing the common carotid as far as the neck of the condyle of the lower jaw. Dissect carefully the styloid muscles and the digastricus; and cautiously separate the artery from the surrounding tissue of the parotid gland.

The *external* or *superficial carotid artery* (*b, fig.* 204.) is in a great measure intended for the face, and has therefore been called the *facial carotid* by Chaussier. It arises from the common carotid, forming one of its two divisions, and extends as far as the neck of the condyle of the lower jaw, where it terminates by dividing into the *temporal* and *internal maxillary* arteries.

Fig. 204.



The origin of this artery is remarkable for being situated on the inner side of the internal carotid. It ascends vertically as high as the digastricus, and passes under that muscle; it is then directed a little backwards and outwards, leaves the vertebral column, reaches the angle of the lower jaw, and again becomes vertical as it proceeds upwards to the neck

of the condyle, opposite to which it terminates. It is very slightly tortuous in the adult, and in the infant is almost straight. In the adult it is nearly equal in size to the internal carotid, but it is much smaller in young subjects. It diminishes rapidly in diameter, on account of the number of branches given off from it, so that at its termination it is scarcely one third its original size. Sometimes it divides immediately into a sort of bunch of arterial vessels; in other cases its branches arise in succession from the common carotid, which is then directly continuous with the internal carotid.

Relations. It is superficial at its origin, like the upper part of the common carotid, and like it is merely separated from the skin by the platysma myoides; but it then dips into the supra-hyoid region, below the digastricus, the stylo-hyoideus, and the hypo-glossal nerve.* Higher up it is situated deeply in the parotid excavation, surrounded on all sides by the tissue of the parotid gland, which, on this account, cannot be entirely extirpated without wounding the vessel.

Collateral branches. These are six in number, and are arranged into three sets; viz. an *anterior* set, consisting of the *superior thyroid*, the *facial*, and the *lingual*; a *posterior*, including the *occipital* and the *auricular*; and an *internal* set, formed by one vessel, the *inferior*, or *ascending pharyngeal.*

The *terminal branches* are two in number, the *superficial temporal* and the *internal maxillary.*

The Superior Thyroid Artery.

The *superior thyroid artery* (*d, fig.* 204.) belongs both to the larynx and the thyroid gland. It is the first branch given off from the external carotid; it rather frequently arises opposite the bifurcation of the common carotid, which in this case would seem to divide into three branches. In some cases it arises directly from the common carotid; at other times it has been seen to come off by a common trunk with the lingual. It is always of considerable size, but varies in this respect, maintaining either a direct relation to the size of the thyroid body, or an inverse proportion to that of the other thyroid arteries.

Direction. It is at first directed horizontally forwards and inwards; but it almost immediately bends, and proceeds vertically to the upper end of the corresponding lobe of the thyroid gland, in which it terminates.

Relations. It is superficial at its origin, where it is covered only by the skin and the platysma; it then dips under the omo-hyoid, sterno-hyoid, and sterno-thyroid muscles, and it is also covered by the cervical fascia and the superior thyroid veins. This artery furnishes several collateral branches, viz. the *superior laryngeal*, the *inferior laryngeal* or *crico-thyroid*, and the *sterno-mastoid* branch.†

The superior laryngeal branch. This (*e*) comes off from the thyroid at the point where the latter changes its direction; sometimes it arises from the external carotid. In certain cases it is so large that it may be regarded as formed by a bifurcation of the thyroid. In one case where it was wanting on the left side, I found it replaced by the right superior thyroid, which was almost double its usual size. This artery passes transversely inwards between the thyro-hyoid muscle and the membrane of the same name, which it perforates along with the superior laryngeal nerve; having reached the cellular tissue behind this membrane, it divides into two branches, an ascending, or *epiglottid* branch, which passes upon the side, then in front of the epiglottis, and ramifies upon it; and a descending, or *laryngeal* branch, properly so called, which passes behind the thyroid cartilage, between it and the thyro-arytenoid muscle, and is distributed upon the muscles and mucous membrane of the

* [It crosses over the styloid process, the stylo-glossus and pharyngeus muscles, and the glosso-pharyngeal nerve, which lie between it and the internal carotid.]

† [The first branch is usually a small one, named the hyoid, which arises opposite the great cornu of the os hyoides, passes inwards on the thyro-hyoid membrane, and anastomoses with the vessel of the opposite side.]

larynx. Not unfrequently the superior laryngeal branch enters the larynx through a foramen, existing in the thyroid cartilage in some subjects.

The *inferior laryngeal* or *crico-thyroid branch.* This arises from the internal terminating branch of the superior thyroid artery; it is more remarkable for its constant presence, than for its size. It is sometimes wanting on one side, but it is then replaced by the superior thyroid artery of the other side. It passes transversely inwards, in front of the crico-thyroid membrane, along the lower border of the thyroid cartilage, and inosculates with the branch of the opposite side. From the arch thus formed twigs proceed, which perforate the crico-thyroid membrane, and ramify in the muscles and the mucous membrane of the larynx.

It is not uncommon to find the inferior laryngeal artery dividing into two branches; one superficial and transverse, the other ascending, which passes up behind the thyroid cartilage.

The sterno-mastoid branch. This is constant, but of variable size. It comes off from the superior thyroid a little below the superior laryngeal, and passes downwards to reach the deep surface of the sterno-mastoid muscle, to which it is distributed.

Terminal branches. Having reached the gland, the thyroid artery divides into three branches, viz. one which passes between the gland and the trachea; another, which proceeds along the outer border of the corresponding lobe; and a third, which runs along the inner border, and anastomoses in the median line with the corresponding branch of the opposite side. It is this vessel which sometimes gives off the inferior laryngeal.*

The Facial or External Maxillary Artery.

The *facial artery* (*f*, *figs.* 204. 206.), so called from its distribution, is given off from the front of the external carotid, a little above the os hyoides: it is so large in some subjects that it seems to be formed by a bifurcation of the external carotid. It proceeds in a tortuous course from below upwards, and then from behind forwards, along a groove formed in the submaxillary gland. After leaving this groove, it passes vertically upwards, crosses the body of the lower jaw at right angles in front of the masseter muscle, becomes oblique, arrives near the commissure of the lips, reaches the furrow between the ala nasi and the cheek, and terminates near the inner angle of the eye, by anastomosing with one of the branches of the ophthalmic, and with the infra-orbital artery. The termination of th facial artery is subject to numerous individual varieties. The vessel is also remarkable for being extremely tortuous, a condition which is connected with the mobility of the parts supplied by this artery, which runs in succession over the supra-hyoid, the inferior maxillary, the buccal, and the nasal regions.

Relations. In the supra-hyoid region the facial artery is covered by the digastric and stylo-hyoid muscles; then, along the base of the jaw, it is in relation with the outer surface of the sub-maxillary gland, and is separated from the skin by the platysma and a great number of lymphatic glands. In the facial region, the artery is covered below by the platysma, higher up by the triangularis oris and the zygomaticus major, and in all the rest of its extent by a greater or less quantity of fat, which separates it from the skin; it lies upon the inferior maxilla, against which it may be compressed in front of the masseter, also upon the buccinator, the orbicularis oris, the levator communis, and the levator proprius.

Collateral branches. The following branches are given off by the facial

* I have seen the branch which runs along the inner border of the thyroid gland pass transversely to the left side, above and at a certain distance from this border; having reached the median line, it proceeded vertically downwards, in front of the crico-thyroid ligament, to the middle of the thyroid gland, where it gave off the right and left inferior laryngeal branches. The left thyroid was very small, and only furnished the external branch for the thyroid gland.

artery in the *supra-hyoid* region. The *inferior palatine*, a small branch which is sometimes derived from the external carotid, or from the ascending pharyngeal artery, passes up behind [or between] the stylo-glossus and stylo-pharyngeus muscles, to which it furnishes some branches, gains the side of the pharynx, and is distributed to the tonsil, which it covers with its ramifications, and also to the velum palati and the pillars of the fauces, opposite which it anastomoses with several branches of the ascending pharyngeal artery. I have seen the palatine branch of the facial extremely large, and taking the place of the tonsillar and palatine branches of the ascending pharyngeal artery.

The *submental branch* (*g*, *fig.* 204.) runs along the inner side of the lower border of the ramus of the jaw, between the digastricus and mylo-hyoideus, passes upwards in front of the bone, on the outer side of the anterior attachment of the digastricus, and ramifies in the skin and muscles of the chin, anastomosing with the ramifications of the inferior dental artery. Sometimes the submental divides into two or three branches, all of which terminate in the same manner, after perforating the digastric muscle.

Branches for the submaxillary gland. These are three or four in number, and are large in proportion to the organ which they supply.

The pterygoid branch. This is a small branch which passes into the internal pterygoid muscle.

The collateral branches of the *facial* region are divided into *external* and *internal*. The *external branches* ramify in all the muscles and integuments of the cheek, and anastomose freely with the transversalis faciei, a branch of the superficial temporal: the most remarkable of these branches are the two given to the masseter and buccinator muscles.

Among the *internal branches*, besides a number of small twigs which have received no names, we remark the following:—

The *inferior coronary*, or *labial* artery (*h*), which is given off from the facial, a little below the commissure of the lips; it pursues a serpentine course in the substance of the lower lip, between the muscular and glandular layers, at a greater or less distance from the free border of the lip, and anastomoses in the median line with the corresponding vessel of the opposite side. I have seen this artery occupy the lower or adherent border of the lower lip until it reached the median line, when it ascended vertically to the free border, where it divided into two equal branches, which passed horizontally, one to the right and the other to the left, in order to form a second coronary artery, smaller than the first.

The *superior coronary*, or *labial*, arises opposite the commissure, passes in the upper lip between the muscular and glandular layers, and inosculates in the median line with the vessel on the opposite side. Branches are given off from this arch to the mucous membrane, the gums, the muscles, and the skin. One branch only of this artery requires a special description; it is known by the name of the *artery of the septum nasi* (*i*). It comes off in the median line by one, two, and sometimes three branches, which pass vertically upwards, and then horizontally beneath the skin, covering the under surface of the septum as far as the tip of the nose, where they anastomose with the artery of the ala.

The *artery of the ala nasi*, or lateral artery of the nose (*l*), which is very often the termination of the facial, divides into two branches, — a small one, that runs along the lower border of the cartilage of the ala, and anastomoses with the artery of the septum; and a larger one, that runs along the upper convex border of that cartilage. A small branch penetrates into the interior of the nares, between the cartilage and the opening of the nostril.

Termination of the facial artery. The facial artery having become extremely slender, sometimes terminates, under the name of the angular branch (*m*), upon the side of the nose, by anastomosing with the nasal branch of the ophthalmic, and with the infra-orbital. At other times its termination is formed by the artery of the ala of the nose, or by the superior coronary of the lip, or even by the inferior coronary. I have seen it terminate in the artery of the septum.

We seldom find the facial arteries of both sides alike. Sometimes there is merely a trace of one, whilst the other is very much developed, and supplies by itself alone all the nasal and labial branches. No artery varies more than the facial, both in size and extent of distribution.

Its anastomoses with the inferior dental and infra-orbital arteries, branches of the internal maxillary, as well as those with the ophthalmic, a branch of the internal carotid, should be particularly noticed.

The Lingual Artery.

Fig. 205.

The *lingual artery* (*n*, *figs.* 204, 205.), which is very large considering the size of the organ to which it is distributed, comes off from the front of the external carotid, between the facial and the superior thyroid, and often by a common trunk with the facial; it passes at first obliquely upwards, and then transversely inwards and forwards, along the upper margin of the corresponding great cornu of the os hyoides: opposite the lesser cornu of that bone it changes its direction, and runs in a serpentine course from behind forwards, in the substance of the tongue as far as the apex, where it terminates by anastomosing with the artery of the opposite side; in the latter part of its course it is named, we know not why, the *ranine artery* (*g*, *fig.* 205.; *rana*, a frog). Its remarkably tortuous course is connected with the liability of the tongue to undergo great changes in its relative dimensions.

Relations. It is deeply seated at its origin under the digastric and stylo-hyoid muscles and the hypo-glossal nerve; opposite the os hyoides (at *n*, *fig.* 205.) it is situated between the hyo-glossus (the nerve passing over that muscle) and the middle constrictor of the pharynx: in the substance of the tongue it is placed between the genio-hyo-glossus and the lingualis, and is accompanied by the lingual branch of the fifth nerve.

Collateral branches. A small transverse branch, the *hyoid* (*e*), forms an anastomotic arch with the vessel of the opposite side, upon the body of the os hyoides, between the genio-hyo-glossus and the genio-hyoideus.

The dorsal artery of the tongue (*f*), generally small and difficult to demonstrate; it arises opposite the great cornu of the os hyoides, ascends upon the lateral border of the tongue, near the anterior pillar of the fauces, to which it gives branches, then passes forwards and inwards, and giving several epiglottid branches, which anastomose with those of the opposite side, is finally distributed to the caliciform papillæ. In the whole of its course, this artery lies immediately beneath the mucous membrane.

The *sublingual artery* (*i*) is large enough to be regarded by some as resulting from the bifurcation of the lingual, which, according to them takes the name of raninal, only after it has furnished the sublingual branch. It arises as often from the facial, by a common trunk with the submental, as from the lingual itself. It passes horizontally forwards between the mylo-hyoideus, which separates it from the submental, and the genio-hyo-glossus, and, in company with the Warthonian duct, runs along the lower border of the sublingual gland, to which it furnishes numerous twigs, and then divides into two branches: the larger, or the *artery of the frænum*, anastomoses in an arch with the vessel of the opposite side above the frænum; while the smaller, or ascending branch, passes upon the sides of the symphysis menti, and sends twigs into the several incisor foramina, situated behind the teeth of the same name. It is this artery of the frænum, not the ranine artery, which is liable to be wounded in division of the frænum. Not unfrequently the sublingual artery gives off a superficial branch, which passes through the anterior belly of the digastricus, and ramifies upon the region of the chin, like the analogous branches of the submental.

Lastly, in the substance of the tongue, the lingual artery gives off superior, internal, and external branches, which supply the muscles and the papillary membrane of that organ.

The Occipital Artery.

The *occipital artery* (*o o, fig.* 204.), which is distributed to the posterior region of the head, is smaller than the three branches of the external carotid already described. It arises from the back of the external carotid, on a level with the lingual or the facial, sometimes immediately below the parotid gland; it passes obliquely upwards and backwards, as high as the apex of the mastoid process; it then passes horizontally backwards, and on the inner side of the splenius muscle, divides into two ascending branches: one external, which immediately bends upwards; the other internal, which is continued horizontally, and is then reflected vertically upwards on the side of the occipital protuberance. These two branches, which are very tortuous, cover the occipital region with their numerous ramifications, and reach as high as the vertex, anastomosing with each other, and with the superficial temporal arteries.

It is situated deeply at its origin, and is covered by the digastric muscle, and the hypo-glossal nerve; it is still more deeply situated as it passes between the mastoid process and the atlas, where it is covered by the digastric and the sterno-mastoid; its horizontal portion is situated between the obliquus capitis superior and the splenius muscle, then between the complexus and the splenius, running along the occipital insertion of the latter muscle, on the inner side of which it becomes subcutaneous. The two branches into which this artery divides, and all its succeeding ramifications, are situated between the skin on the one hand, and the occipital muscle and the occipito-frontal aponeurosis on the other.

Collateral branches. Among a great number of small and unnamed ramusculi, we shall distinguish the following branches: a *superior sterno-mastoid artery*, which constantly exists, but is sometimes given off from the external carotid itself; it forms a curve, with its concavity directed downwards, under which the hypo-glossal nerve turns; it then penetrates the deep surface of the upper portion of the sterno-mastoid: a *stylo-mastoid branch*, which is often derived from the posterior auricular artery: a *meningeal artery*, or *posterior mastoid*, which enters the cranium, either by the foramen mastoideum, the foramen lacerum posterius, or even the foramen magnum, and is distributed to the dura mater: a *cervical artery* (*princeps cervicis*), which descends between the splenius and complexus muscles, and may be followed down to the lower part of the neck; this branch is sometimes of considerable size: lastly, very often, a terminal branch, the *parietal*, which enters the cranium by the parietal foramen, and ramifies in that portion of the dura mater which forms the superior longitudinal sinus.

The Posterior Auricular Artery.

The *posterior auricular artery* (*s, fig.* 204.) is intended for the pinna, the internal ear, and the neighbouring parts of the cranium; it is usually smaller than the occipital, but is sometimes as large; it arises from the back of the external carotid, a little above the occipital, and rather often by a common trunk with that artery. It passes vertically upwards, being deeply seated under the digastricus; it is then covered by the parotid gland, which it perforates to gain the posterior border of the mastoid process, upon which it divides into two branches, a *mastoid* and an *auricular*.

In this course it gives off several *parotid* and *muscular* branches, and the stylo-mastoid artery, which is sometimes derived from the occipital. The *stylo-mastoid artery*, so remarkable for the length of its course, dips into the stylo-mastoid foramen, runs the whole length of the aqueduct of Fallopius, giving off, as it proceeds, some twigs to the internal ear, and terminates by

anastomosing with a branch of the middle meningeal artery, which enters by the aqueduct of Fallopius.

The *terminal mastoid branch* of the posterior auricular passes upwards and backwards between the mastoid process and the skin, and subdivides into two subcutaneous ramusculi: one horizontal, which passes inwards along the occipital attachment of the sterno-mastoid and splenius; the other ascending, which continues in the original course of the vessel, and is lost in the skin upon the outer margin of the occipitalis muscle.

The *terminal auricular branch* almost always divides into two: a *superior* and an *inferior*. The *superior* branch runs along the anterior border of the mastoid process, ramifies upon the upper half of the internal surface of the pinna, and turns round its free margin, so as to reach the external surface. The *inferior* branch passes behind the auditory meatus, supplies the lobule of the ear, insinuates itself into the fissure in the cartilage, between the helix and concha, and thus gains the external surface of the pinna, upon which it passes upwards in the furrow between the helix and antihelix. It terminates by anastomosing with the superior branch.

I have seen the auricular artery of great size, to supply the place of the posterior branch of the superficial temporal.

The Parotid Arteries.

Whilst passing through the parotid gland, the external carotid gives off four or five large branches to that organ, which deserve special description. They arise from the carotid at right angles, cross the ramus of the lower jaw also at right angles, and divide into a great number of ramifications, most of which are lost in the substance of the gland; the remainder are distributed to the skin and muscles. One or more of these branches pass between the parotid gland and the masseter muscle, parallel to the transversalis faciei artery, and reach as far as the zygomaticus major; others gain the angle of the jaw, and are lost in the supra-hyoid region.

The Inferior or Ascending Pharyngeal, or Pharyngo-meningeal Artery.

Dissection. Make the section necessary for examining the pharynx (see p. 283.): the steps required for this purpose render it advisable that the study of this artery should be postponed until after that of the internal maxillary.

The *ascending pharyngeal* is the smallest branch of the external carotid; it arises from the inner side of that artery opposite the lingual. I have seen it arise from the occipital. Not unfrequently it is given off either from the angle of bifurcation of the common carotid, or from the internal carotid; and in this last case there is almost always a very small pharyngeal branch arising from the external carotid, and passing transversely inwards to the pharynx.

It varies in size to a certain degree, and, as it appears to me, in an inverse ratio to that of the palatine branch of the facial. I have seen it almost as large as the occipital.

Immediately after its commencement the ascending pharyngeal passes vertically upwards, at first between the external and internal carotid, and then behind the internal carotid, with which latter vessel it is found in the triangular interval between the pharynx and the internal pterygoid muscle; it then almost immediately divides into two branches, a *meningeal* and a *pharyngeal.*

Before dividing, it gives off an *inferior pharyngeal branch,* which passes transversely inwards, and subdivides into ascending and descending branches, the latter of which anastomose on the pharynx with some twigs of the superior thyroid.

The *meningeal branch,* which is situated behind the internal carotid, passes vertically upwards, gives off twigs to the superior cervical ganglion of the

sympathetic nerve, to the pneumogastric, glosso-pharyngeal, and hypo-glossal nerves, and to the accessory nerve of Willis, enters the cranium through the foramen lacerum posterius, and ramifies upon that portion of the dura mater which lines the inferior occipital fossa. I have seen this vessel divide into a great number of branches, one of which entered the cranium by the carotid canal, and another by the foramen lacerum anterius.

The meningeal branch, and sometimes even the trunk of the pharyngeal, gives off a *prævertebral branch*, which passes upwards in front of the longus colli and the recti antici major et minor, supplying these muscles, and anastomosing with the cervicalis ascendens. I have traced a branch into the cranium through the first intervertebral foramen (*i. e.* along the superior notch of the atlas), and another which entered the vertebral canal between the atlas and axis. I regard this prævertebral branch as supplementary to the cervicalis ascendens (a branch of the inferior thyroid), for it has a similar distribution.

The *pharyngeal branch* passes in front of the internal carotid, and having reached the base of the cranium, divides into numerous branches, which ramify in the very dense fibrous tissue, found at the occipital attachment of the pharynx: they are all reflected downwards, and are distributed upon the Eustachian tube and the muscles of the pharynx. In a case in which the palatine branch of the facial artery was absent, this pharyngeal branch was very large and supplied the tonsil, and finally ramified in the velum palati.

The Temporal Artery.

Dissection. Turn back the parotid gland; seek for the artery under the skin of the temporal region; follow its different collateral and terminal branches upon the cranium as far as the vertex, on the face, and on the ear.

The *temporal* or *superficial temporal artery* (*p, fig.* 204.) appears by its direction to form the continuation of the external carotid. It commences opposite the neck of the condyle of the lower jaw, between it and the external auditory meatus, which is behind; it passes vertically upwards, immediately behind the zygomatic arch, reaches the temporal region, where it describes some curves still continuing its vertical course, and terminates by bifurcating at the middle or sometimes the upper part of that region.

Relations. It is covered at its origin by the parotid gland; it becomes subcutaneous as soon as it passes beyond the zygomatic arch, and then rests upon the temporal fascia at first, and upon the epicranial aponeurosis afterwards. Its superficial position, added to its proximity to a bony surface, render it easily compressible, and explain why this artery, and especially its anterior or frontal branch, is generally chosen for arteriotomy.

Collateral branches. These are divided into anterior, posterior, and internal.

The anterior branches. The most remarkable of these is the *transversalis faciei* (*u*), which arises from the temporal immediately after its origin, opposite the neck of the condyle of the lower jaw, and consequently in the substance of the parotid gland; it very often comes directly from the external carotid. It varies much in its size, which is generally in an inverse proportion to that of the facial artery. It proceeds horizontally forwards, across the direction of the neck of the condyle and the masseter muscle, about six lines below the zygoma, above the Stenonian duct, which runs parallel to it. The transversalis faciei gives an articular branch to the temporo-maxillary articulation, and *several deep masseteric branches*, of which one of considerable size penetrates the back part of the muscle, and anastomoses with the masseteric branch of the internal maxillary. It also gives a small twig, which runs along the Stenonian duct. At the anterior margin of the masseter the transverse facial artery subdivides into a great number of *cutaneous, muscular*, and *anastomotic branches.* Among the first we should notice a *malar cutaneous branch;* and among the muscular branches, those which are distributed to the great zygomatic muscle. The muscular

branches of the transversalis faciei may be traced in one direction as far as the orbicularis palpebrarum, and in another into the levator proprius läbii superioris. The anastomotic branches establish an intimate communication between the temporal artery and the buccal, infra-orbital, and facial arteries.

A second anterior branch of the temporal artery also requires special notice, viz. the *orbital*, which is given off above the zygomatic arch, passes from behind forwards, between the superficial and deep layers of the temporal fascia, then behind the orbicularis muscle, which it supplies, as well as the corresponding skin, and anastomoses with the superior palpebral branch of the ophthalmic. This artery is very variable in regard to size. I have seen it very large and reflected upwards, between the frontalis muscle and the skin, parallel to the supra-orbital branch of the ophthalmic, and capable of being followed as far as the parietal region. From the bend which it forms by turning upwards, it gives off a palpebral branch, which completes the superior palpebral arch, and also a branch which anastomoses with the supra-orbital. This orbital branch of the temporal does not exist in all subjects; the branches which it furnishes are then given off directly from the temporal.

The *posterior branches* consist of the *anterior auriculars* (*v*), which are irregular as to number; the lower branches are distributed to the lobule, the middle ones to the external auditory meatus, and the upper branches to the highest part of the pinna.

The *internal branch* is the *middle deep* or sub-aponeurotic *temporal* artery; it arises from the temporal above, sometimes on a level with the zygoma, perforates the fascia, and is distributed to the temporal muscle, anastomosing with the anterior and posterior deep temporal branches derived from the internal maxillary.

Terminal branches. Of the two branches into which the temporal artery divides, the *anterior* or *frontal* (*q*) passes forwards and upwards towards the frontal region, upon which it ramifies, anastomosing with the branches of the frontal and supra-orbital arteries, and with the temporal of the opposite side. This branch is divided in the operation of arteriotomy. The *posterior* or *parietal branch* (*y*) is larger than the anterior; it passes upwards and ramifies upon the parietal bone, anastomosing with the auricular and occipital arteries, with the frontal branch of the temporal, and with the temporal of the opposite side. It is sometimes derived from the auricular artery.

The Internal Maxillary Artery.

Dissection. Saw through the zygomatic arch in two places, and turn it downwards together with the masseter muscle, taking care not to tear the masseteric artery.

Dissect the temporal muscle, and saw through the coronoid process of the inferior maxilla. Saw through the cranium circularly, and remove the brain, which may be put into diluted nitric acid or alcohol, to be hardened for the subsequent dissection of the cerebral arteries. The artery may then be exposed in two ways, either from the outer or else from the upper wall of the zygomatic fossa.

It may be reached from the outer wall of the zygomatic fossa by sawing through the lower jaw in front of the masseter, by disarticulating the condyle, or rather by sawing it across its neck, and by carefully dissecting the pterygoid muscles.

The artery can be reached from the upper wall by making two sections in this part of the bone, which will meet at an acute angle in the foramen spinosum of the sphenoid bone.

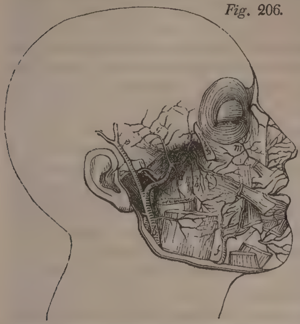
The branches of this artery, especially those which are inclosed in bony canals, such as the dental, the pterygo-palatine, the vidian, &c. must be dissected by carving out their courses in the bone.

A vertical section, made from before backwards through the middle of the

face, facilitates the examination of this artery, and enables us to see the terminations of its nasal, palatine, and pharyngeal branches.

The *internal maxillary artery* (*e*, *fig*. 206.), little known to the older anatomists, but accurately described by Haller, is the continuation of the external carotid, at least, as far as size is concerned.

Fig. 206.



Immediately after its origin it forms a curve, and passes deeply to the inner side of the neck of the condyle of the lower jaw.

Tortuous and horizontal in the first part of its course, it traverses the zygomato-maxillary fossa diagonally, passes forwards, inwards, and a little upwards, to reach the highest part of the tuberosity of the superior maxillary bone, upon which tuberosity it describes a very considerable curve with the convexity turned forwards; and then dips into the bottom of the zygomatic fossa, *i. e.* the spheno-maxillary fossa, where it terminates by one or several branches, called the spheno-palatine. The tortuous course of the internal maxillary is connected with the great number of branches given off from it.

Relations. Opposite the neck of the condyle it is situated between the condyle, to which it is applied, and the styloid process — an important relation in a surgical point of view. Its relations in the zygomato-maxillary fossa are not very definite. Some anatomists, with Bichat and Meckel, state that it is situated between the internal and external pterygoid muscles; others, with Haller, that it is placed in front of the external pterygoid, *i. e.* between that muscle and the temporal. Both modes of distribution are equally common, and I have even seen one existing on the right, and the other on the left side in the same subject. If the internal maxillary is situated between the pterygoids, it passes directly forwards, on the outside of the dental and lingual nerves; when it has to get between the external pterygoid and the temporal, it bends downwards and then upwards, so as to embrace the lower half of the circumference of the external pterygoid: in this manner it gains the outer surface of that muscle, appears opposite the sigmoid notch of the lower jaw, and passes from behind forwards, between the external pterygoid and temporal muscles; in both cases it passes between the two origins of the external pterygoid, in order to reach the pterygo-maxillary fissure.

Collateral branches. These are thirteen in number, and are divided into those arising on the inner side, and near the neck of the condyle, viz. the *tympanic*, the *middle meningeal*, and *inferior dental*, the *posterior deep temporal*, the *masseteric*, the *pterygoids*, and the small *meningeal* arteries; those arising near the maxillary tuberosity, viz. the *buccal*, the *anterior deep temporal*, the *alveolar*, and the *infra-orbital* arteries; and those arising within the spheno-maxillary fossa, viz. the *vidian* or *pterygoid*, the *pterygo-palatine*, and the *superior palatine* arteries.

Branches arising near the Neck of the Condyle.

The *tympanic* artery is a very small branch, which sometimes arises from the temporal, and sometimes from the inferior dental; it is distributed to the external auditory meatus and the temporo-maxillary articulation, and penetrates through the Glasserian fissure into the cavity of the tympanum, to the muscles and walls of which it sends its ramifications.

The *middle* or *great meningeal artery*, or spheno-spinous artery, is destined for the dura mater and the bones of the cranium; it almost always arises from the internal maxillary before the dental, but sometimes in the same

situation; it passes vertically upwards behind the neck of the condyle, and gains the foramen spinosum in the sphenoid bone, through which it enters into the interior of the cranium; it is then reflected upon the anterior margin of this foramen, becomes horizontal, and divides into two branches, an *anterior* and a *posterior*. The *anterior* branch is the larger; it runs upon the outer extremity of the lesser wing of the sphenoid, and reaches the anterior angle of the parietal bone, where it is received into an imperfect, and sometimes even into a complete bony canal, and then divides and subdivides in the ramified grooves upon the internal surface of the parietal bone. Its branches may be traced even into the walls of the longitudinal sinus.

The *posterior branch* is smaller, and passes backwards and upwards upon the squamous portion of the temporal bone, and upon the internal surface of the parietal bone, enters into the ramified grooves upon that surface, and terminates in the dura mater and the bones of the cranium. The ultimate twigs of the middle meningeal artery anastomose with those of the opposite side, and with the branches of the anterior and posterior meningeal arteries.

Relations. In the first part of its course it is very deeply situated, and is in relation in front with the condyloid attachments of the external pterygoid muscle; in the cranium it is situated on the outer surface of the dura mater, between that membrane and the bones, into the substance of which it sends a number of extremely fine ramusculi. The relation of the two divisions of this artery with the two inferior angles of the parietal bone, deserves notice in a surgical point of view. In consequence of its sending branches into the bones, separation of the dura mater is always followed by effusion of blood.

The middle meningeal artery also gives off some *collateral* branches. On the outside of the cranium it furnishes some unnamed twigs. Within the cranium it gives a small branch named the *vidian*, which enters the aqueduct of Fallopius through the *hiatus Fallopii*, and supplies the facial nerve, ramifying in its neurilemma, and anastomosing with the stylo-mastoid branch of the occipital artery; some small branches, which supply the fifth or trigeminal nerve, and evidently anastomose with the meningeal branches of the internal carotid; a small twig which enters the canal for the internal muscle of the malleus, and is distributed upon that muscle; opposite the sphenoidal fissure, several *orbital* branches, which enter the orbit at the narrowest part of that fissure, or even by proper canals in its neighbourhood; and lastly, some rather large *temporal* branches, which pass into the great alæ of the sphenoid at their orbital surface, and anastomose in the temporal fossa with the deep temporal arteries: not unfrequently the lachrymal artery, or a small supplementary lachrymal artery is furnished by the middle meningeal.

The *inferior dental artery* (*d*) is the artery of the lower jaw; it generally arises on a level with the middle meningeal, but sometimes before and sometimes after that vessel; it passes downwards, along the inner surface of the ramus of the jaw, between the bone and the internal pterygoid, sending off branches to that muscle, but being separated from it by the fibrous band called the spheno-maxillary ligament; it thus reaches the superior orifice of the dental canal, before entering which it gives off a small branch that passes downwards and forwards in a groove on the inner surface of the jaw, and terminates in the mylo-hyoid muscle.

The inferior dental artery traverses the entire length of the dental canal, accompanied by the nerve of same name. Opposite the bicuspid teeth it divides into two branches: a *mental* branch, the larger, which escapes through the mental foramen, and anastomoses with the sub-mental artery and the inferior coronary artery of the lip; and an *incisor* branch, which continues in the original course of the artery, passes beneath the canine and incisor teeth, and is lost in the diploe opposite the symphysis.

During its course the dental artery, as well as its incisor branch, gives off a great number of twigs, which are lost in the diploe of the bone; and a series of *dental branches*, which correspond in number with the roots of the teeth

penetrate into the alveoli, and from thence into the teeth through the foramen observed at the apex of each fang.

The *posterior deep temporal artery* (*g*) arises opposite the sigmoid notch, passes vertically upwards, between the external pterygoid and the temporal muscles, gains the posterior border of the latter muscle, gets between that border and the temporal fossa, remains in contact with the periosteum, and then divides and subdivides, so as to terminate partly in the temporal muscle and partly upon the periosteum, anastomosing with the middle and anterior deep temporal arteries. It often gives off the masseteric, and sometimes the buccal artery.

The *masseteric artery* is a small branch, the size of which is inversely proportioned to that of the masseteric branch of the transversalis faciei. It often arises by a common trunk with the posterior deep temporal, passes outwards in front of the condyle, and therefore in the notch between the condyle and the coronoid process, and enters the internal surface of the masseter, in which muscle it anastomoses with the masseteric branches given off by the transversalis faciei and facial arteries.

The *pterygoid arteries* are irregular in number; some of them arise directly from the internal maxillary, others from the posterior deep temporal and the middle meningeal.

The *small meningeal artery* is not constant, but I have seen it in one case as large as the middle meningeal; it arises at the same height as the inferior dental, passes between the pterygoid muscles, and divides into two branches: one of which turns round the origin of the internal pterygoid, and terminates in the velum palati and the nasal fossæ; and another which passes vertically upwards, between the external pterygoid and the upper wall of the zygomatic fossa, enters the cranium by the foramen ovale, and supplies the trigeminal nerve and the dura mater, anastomosing with small branches given off from the internal carotid.

Branches arising near the Tuberosity of the Superior Maxillary Bone.

The *buccal artery* (*h*) is a small branch of variable size, and sometimes exists only in a rudimentary state. It rather frequently arises by a common trunk with the superior dental artery, passes in a tortuous course from behind forwards, between the ramus of the lower jaw and the internal pterygoid muscle, emerges in front of the ramus, and is lost in the buccinator muscle, anastomosing with the buccal branches of the facial and transversalis faciei.

The *anterior deep temporal artery* (*i*) is of considerable size; it passes vertically upwards, along the anterior border of the temporal muscle, with which it is in contact, is lost in that muscle, anastomosing with the posterior deep temporal and the middle temporal. It gives off some extremely delicate orbital branches, which traverse the canals in the malar bone, and are lost in the adipose tissue of the orbit.

The *alveolar* or *superior dental* (*l*) often arises by a common trunk with the infra-orbital, passes in a very tortuous manner forwards and downwards upon the tuberosity of the superior maxilla, and divides into several branches; some of these having reached the alveolar border, are reflected upon the margins of the alveoli, pass into their cavities, and ramify in the alveolo-dental periosteum; other branches enter the small posterior dental canals, penetrate into the alveoli of the molars and bicuspids, and divide into as many ramusculi as there are roots to each of those teeth. Several of these branches penetrate into the maxillary sinus. I have seen one which ran along this sinus from behind forwards near its lower wall, was reflected upwards on the anterior wall of the same cavity, and entered the base of the ascending process of the superior maxilla, at which point I could no longer follow it. This branch was situated between the lining membrane of the sinus and the bones. Lastly, some very delicate twigs of the superior dental artery enter the buccinator muscle.

The *infra-orbital artery* arises from the internal maxillary opposite the spheno-maxillary fissure, sometimes alone, sometimes by a common trunk with the superior dental, immediately enters and then traverses the infra-orbital canal, emerges at the infra-orbital foramen, and divides into a great number of branches (*m*) which are distributed to the skin and mucous membrane of the cheek, anastomosing with the facial artery, the transversalis faciei, and the alveolar and buccal branches just described. Several branches enter the alveoli of the canine and incisor teeth at their borders: others penetrate into the nasal fossæ at the nostril.

During its course, the infra-orbital artery furnishes a very remarkable branch, which enters the cavity of the orbits, where it divides into two branches, one of which passes directly forwards and is lost in the lower eyelid, while the other, which is larger, turns inwards and inosculates with the inferior palpebral branch of the ophthalmic artery; another branch of the infra-orbital artery enters the anterior dental canal, to supply the canine and incisor teeth, penetrating into the foramina at the points of their fangs, in the same way as in the other teeth.

Branches arising in the Pterygo-maxillary Fossa.

The *vidian* or *pterygoid artery* is a very small vessel, which, immediately after its commencement, enters the vidian canal, traverses its whole length, and then ramifies in the pharynx and around the Eustachian tube.

The *pterygo-palatine artery* is as small as the preceding, below and to the inner side of which it is situated; it traverses the pterygo-palatine canal, and terminates in the pharynx and on the Eustachian tube. It sometimes arises from the spheno-palatine artery.

The *superior palatine artery* is larger than the preceding branches, and pursues a downward course; it arises opposite the pterygo-maxillary fissure, passes vertically downwards, enters the posterior palatine canal, and having emerged from its inferior orifice, is reflected from behind forwards, advances in a tortuous manner (*r*, *fig.* 205.) between the hard palate and the mucous membrane, in the groove which runs along the alveolar border, and forms an anastomotic arch in the median line, with the palatine artery of the opposite side. Before entering the posterior palatine canal, it gives off some branches which run through the accessory palatine canals, and ramify upon the velum palati. Whilst upon the hard palate, it sends off branches, which are distributed to the glands of the mucous membrane; others, which are distributed to the gums, and enter at the margins of the alveoli, and supply the alveolo-dental periosteum; and lastly, a small *nasal branch* (*t*, *fig.* 205.), which enters the anterior palatine canal, bifurcates above like that canal itself, so as to penetrate into each of the nasal fossæ, and anastomoses with the spheno-palatine artery of both sides.*

Terminal Branch of the Internal Maxillary Artery.

This is named the *spheno-palatine;* it is a large vessel, often multiple, and is intended exclusively for the pituitary membrane; it passes from below upwards, in a tortuous manner, to penetrate the corresponding nasal fossa, by the spheno-palatine foramen, that is, at the back part of the superior meatus, where it immediately divides into two branches; one internal (*s*, *fig.* 205.), which passes obliquely downwards and forwards, covers the septum with a complicated network, and anastomoses in front with the nasal branch of the superior palatine; the other external, which divides into three ramusculi for the three meatuses, and ramifies in them and upon the turbinated bones. Some of the twigs enter the sphenoidal and maxillary sinuses, the posterior and the anterior ethmoidal cells, the frontal sinus, and the lachrymal canal.

* There are in the interior of the bones of the face, as in all spongy bones, true arterial canals, the study of which is not less important than that of the venous canals found in similar situations.

All these arteries form areolæ of different sizes in the pituitary membrane, and give it, in successful injections, a reticulated aspect; they are situated between the periosteum and the pituitary membrane, properly so called. The arteries of the turbinated bones are lodged in the areolar cells on the surface of those bones, and in the arterial canals which are hollowed out of them.

Summary of the Distribution of the Internal Maxillary Artery.

The internal maxillary sends branches to the organs of mastication and deglutition, to the nasal fossæ, to the bones and fibrous membranes of the cranium, to the face, and to the organ of hearing. Its different branches are distributed in the following manner:—

To the passive instruments of mastication, viz. the jaws and teeth, the *inferior dental*, the *superior dental*, and the *infra-orbital arteries*; to the active organs concerned in that process, the *masseteric*, the *anterior* and *posterior deep temporal*, and the *pterygoid arteries.*

To the organs of deglutition, viz. the hard and soft palate and the pharynx, the *superior palatine*, the *small meningeal*, the *vidian*, and the *pterygo-palatine arteries.*

To the nasal fossæ, some branches of the *infra-orbital*, and the whole of the *spheno-palatine artery*; the latter vessel, and consequently the internal maxillary artery also, are very large in those animals which have a highly developed olfactory apparatus.

To the organ of hearing, the *tympanic artery*, *those branches of the middle meningeal* which enter the hiatus Fallopii, and also those which enter the canal of the internal muscle of the malleus.

To the face, viz. to the muscles and integuments, the *buccal*, the *infra-orbital*, and the *mental arteries.* The region of the eye is the only part not supplied by the internal maxillary.

To the bones of the cranium, and to the dura mater, the *middle and the small meningeal arteries.*

The Internal Carotid.

Dissection. The simplest method of exposing this vessel is to make the section for examining the pharynx (see p. 283.). The carotid canal must be opened with a chisel, and the outer wall of the cavernous sinus removed.

The *internal carotid* is distributed to the anterior part of the brain, and to the eye and its appendages.

It is one of the two branches into which the common carotid divides: situated, at its origin, on the outside of the external carotid, it passes sometimes vertically upwards, parallel to, and in contact with, that artery, and sometimes behind it, by crossing it at an acute angle opposite the digastric muscle; it then leaves the external carotid to pass deeply into the triangular space between the pharynx and the ramus of the lower jaw, and reaches the base of the cranium, into which it penetrates by the carotid canal. After emerging from this canal, it is situated in the cavernous sinus, upon the sides of the sella turcica, is reflected upwards on the inner side of the anterior clinoid process, and terminates by dividing into three branches.

The size of this artery, which is always exactly proportioned to that of the brain, is in the adult equal to that of the external carotid; in the infant it is much larger (ramus grandior carotidis, *Vesal.*). In man, as in the whole series of animals, the relative size of the internal and external carotids is determined by the relative developement of the brain and the face. The internal carotid is remarkable for retaining the same diameter from its commencement to its termination.

Its *direction* is generally straight until it reaches the base of the cranium, but sometimes it describes a single curve immediately after its commencement, sometimes several curves having opposite directions. At the base of the

cranium, before entering the carotid canal, it becomes horizontal, and then vertical and ascending.

In traversing the carotid canal, it follows the angular course of that passage; in the cavernous sinus, it passes directly forwards and upwards, like the carotid groove; at other times it describes two distinct curves; lastly, on the inside of the anterior clinoid process, it is reflected directly upwards and a little backwards. The double curvature which it describes in traversing the carotid canal and the cavernous sinus, has been well compared to the Roman letter S. The numerous inflexions of the internal carotid form one of the most decided arguments in favour of the opinion that the use of these windings is to retard the passage of the blood.

Relations; from its origin to the base of the cranium. At its *origin*, the internal carotid is situated as superficially as the termination of the common carotid, and is crossed by the hypoglossal nerve and the occipital artery, it soon passes behind the external carotid, and becomes deeper and deeper. Protected by its position in the triangular space, which is bounded on the inside by the pharynx, and on the outside by the ramus of the lower jaw, it rests behind upon the vertebral column, from which it is separated by the prævertebral muscles and aponeurosis: it is in relation in front and to the outer side with the stylo-glossus and stylo-pharyngeus muscles, which pass between it and the external carotid; on the inside, with the pharynx; and on the outside and behind, with the internal jugular vein. The ascending pharyngeal artery is, moreover, in relation with it behind, and the great sympathetic nerve on the inside: the pneumogastric, glosso-pharyngeal, and hypoglossal nerves, are situated behind the internal carotid at their exit from the cranium, but soon get to its outer side, between it and the internal jugular vein.

The relation of the artery with the external surface of the pharynx explains how this vessel may be wounded from the interior of that cavity. Sometimes one of its curves approaches the region of the tonsil; and this may, perhaps, have been the case, when the artery has been wounded by an instrument directed transversely outwards and carried into the tonsil, either to open an abscess or to excise the gland.

In the *carotid canal*, the artery is in relation with the nervous filaments ascending from the superior cervical ganglion. A very thin fibrous lamina, a prolongation of the dura mater, separates the vessel from the bony walls of the canal. Its proximity to the internal ear whilst traversing the petrous portion of the temporal bone, is probably the cause of the arterial pulsations which are heard in certain cases.

In the *cavernous sinus*, the artery is applied against the inner wall of that cavity, and is therefore placed on the inner side of the nerves which pass through the sinus, and more particularly of the sixth pair; it is said that the artery is not bathed in the blood contained in the sinus, but is protected from it by a very thin layer of membrane, continuous with the internal coat of the veins. However careful I may have been, I have never succeeded in separating this membrane.

On the inner side of the anterior clinoid process, the artery is upon the outer side of the optic nerve, and at the point where it emerges from the dura mater, above the anterior clinoid process, it is received in a sheath formed by the arachnoid.

Branches of the internal carotid. On the outside of the cranium, it gives off no branch, excepting in a few cases where it furnishes the ascending pharyngeal, or, rather, only a supplementary pharyngeal branch; and lastly, when it gives off the occipital. In the carotid canal it sends a twig into the cavity of the tympanum by a special opening. In the cavernous sinus it furnishes several small branches (*arteriæ receptaculi*), some of which are reticulated, and distributed to that portion of the dura mater which lines the basilar surface of the occipital bone, and to the walls of the inferior petrosal sinus; whilst others ramify upon the pituitary body, the fifth pair of nerves, and the adjacent por-

tion of the dura mater: a larger branch anastomoses with the middle meningeal artery.

Lastly, on the inner side of the anterior clinoid process, just as it passes above that process, the internal carotid gives off in front a remarkable artery, named the *ophthalmic*.

The Ophthalmic Artery.

Dissection. Make a partial injection, either from the common or internal carotid. Remove the roof of the orbit, after having carefully detached the integuments and periosteum of the frontal region; leave a small bridge of bone on the inner part of the margin of the orbit for the supra-orbital artery, or rather open the supra-orbital foramen and disengage the artery from it. Dissect the muscles of the eye with great care, preserving all the vessels which present themselves. The study of the branches of the ophthalmic artery, which are distributed to the ball of the eye, requires a perfect knowledge of that organ.

This artery is principally destined for the eye and its appendages, and is less remarkable for its size, which is inconsiderable, than for the number of its branches. Immediately after its origin, it enters the optic foramen (*b*, *fig.* 207.), on the outer side of and below the optic nerve. The artery is at first contained in the same sheath as the nerve, but soon escaping from it, penetrates into the orbit between the abducens oculi nerve and the external rectus muscle of the eye, turns inwards and crosses the optic nerve, sometimes at right angles and sometimes obliquely, and is then placed above the nerve. Having reached the inner wall of the orbit, it again changes its direction, passes horizontally and in a slightly tortuous manner along the lower border of the superior oblique muscle of the eye, and terminates by bifurcating at the margin of the orbit. Not unfrequently the ophthalmic artery, immediately after its origin, is placed on the inner side of and below the optic nerve, and then passes directly forwards along the inner side of that nerve; so that, in these cases, the nerve and artery do not cross each other.

Fig. 207.

The ophthalmic artery gives off a great number of branches, which, according to their origin, may be divided into those arising on the outside of the optic nerve, viz. *the lachrymal artery and the central artery of the retina*; those arising above the nerve, viz. *the supra-orbital, the short ciliary, the middle or anterior ciliary, the superior and the inferior muscular arteries;* those arising on the inner side of the optic nerve, viz. *the posterior and anterior ethmoidal and the inferior and superior palpebral arteries*; in all, eleven branches, to which may be added the terminal branches, viz. *the nasal and the frontal arteries.* It is well to remark, that the origins of most of the above-named branches are subject to extreme variety.

Branches arising on the outer side of the optic nerve. The *lachrymal artery* (*c*, *fig.* 207.), one of the largest branches of the ophthalmic, arises immediately before the entrance of the latter into the orbit. Not unfrequently it is given off from the middle meningeal artery.

The lachrymal artery passes from behind forwards along the outer wall of the orbit, between the periosteum and the external rectus muscle, and enters the lachrymal gland (*l*), supplying it with a great number of branches. Emerging from the gland very much reduced in size, it terminates partly in the conjunctiva, and partly in the structures composing the upper eyelid.

In its course it sometimes gives off a small meningeal branch, which passes backwards through the sphenoidal fissure, and enters the dura mater, in which it anastomoses with the middle meningeal artery. This branch may be considered, in some subjects, as one origin of the lachrymal artery; a condition

that leads to those cases in which the lachrymal artery arises from the middle meningeal. It often gives off a long ciliary artery, and always some twigs to the neurilemma of the optic nerve, and muscular branches to the levator palpebræ superioris and the superior rectus; lastly, it furnishes a muscular branch, the *malar*, which perforates the malar bone, and anastomoses in the temporal fossa with the anterior deep temporal artery, and upon the malar bone itself with the transversalis faciei.

The *central artery of the retina* (*arteria centralis retinæ*; *i*), quite distinct from the twigs supplied to the neurilemma of the optic nerve, is an extremely delicate vessel; it arises either from the ophthalmic, or from one of the ciliary arteries, penetrates obliquely into the substance of the nerve, runs along its centre from behind forwards, enters into the globe of the eye, and expands in diverging ramifications, which are applied to the internal surface of the retina, and accompany it as far as the ciliary processes. A branch very distinct from those just mentioned traverses the vitreous body from behind forwards, in the axis of the eye, and reaches the capsule of the crystalline lens, after having furnished some extremely fine twigs to the hyaloid membrane.

Branches arising above the optic nerve. The *supra-orbital* or *superciliary* artery (*d*) arises from the ophthalmic as that vessel is crossing the optic nerve; it is sometimes given off from the lachrymal. It is very variable in size, and appears in certain cases to be partially replaced by the orbital branch of the temporal, or by the frontal branch of the ophthalmic. It passes horizontally between the periosteum of the roof of the orbit and the levator palpebræ superioris, accompanied by the frontal nerve; it escapes from the orbit at the superciliary notch, is reflected over it as over a pulley, ascends vertically, and divides into two branches, one of which passes upwards between the skin and the orbicularis and occipito-frontalis muscles, and the other is situated between the muscles and the periosteum, and ramifies in that membrane. The subcutaneous branch often divides into an internal and an external twig. It is also said constantly to furnish a branch to the diploe of the frontal bone, as it is passing through the superciliary notch. It appears to me that this branch is often wanting.

The *ciliary arteries* may be divided into the *posterior* or *short*, the *middle* or *long*, and the *anterior*.

The *posterior ciliary* arteries (*r*) distributed to the choroid coat and the ciliary processes (artères uvéales, *Chauss.*) are irregular in number, which is stated to be thirty or even forty; they arise from two trunks, one inferior which is given off from the ophthalmic artery on the outer side of the optic nerve; the other is superior and arises above that nerve. Not unfrequently the lachrymal artery gives off the inferior long ciliary trunk. They run in a very tortuous course along the optic nerve, and having reached the ball of the eye, twist spirally and immediately expand into a tuft of tortuous ramusculi which surround the optic nerve, perforate the sclerotic coat around the entrance of the nerve, and then ramify, as will be elsewhere stated, in the choroid coat and ciliary processes.

The *middle* or *long ciliary* arteries (artères iriennes, *Chauss.*), which are distributed to the iris, are two in number, an internal and an external; they perforate the sclerotic at some distance from the optic nerve, and pass between the sclerotic and the choroid membrane on the sides of the eyeball. Having reached the ciliary ring, each of them divides into two branches which anastomose together, and form the great vascular circle of the iris. Numerous radiating branches proceed from all points of the inner border of this circle towards the free margin of the iris, where they subdivide and anastomose to form the lesser vascular circle of that membrane.

The *anterior ciliary arteries* are irregular in number, and are derived from the muscular branches, and sometimes from the lachrymal and infra-orbital; they give some branches to the conjunctiva, penetrate the sclerotic at a short distance from the cornea, and terminate in the great circle of the iris.

The *muscular arteries* are two, viz. the superior and the inferior. The *superior* is the smaller; it is often wanting, and is then replaced by branches from the lachrymal, infra-orbital, or ciliary arteries. It is distributed to the levator palpebræ superioris, the superior rectus, and the obliquus superior. The *inferior* which always exists, passes from behind forwards between the optic nerve and the inferior rectus, gives off most of the anterior ciliary arteries, and is distributed to the external and inferior recti and to the obliquus inferior. Sometimes the inferior muscular is not entirely distributed to the muscles, but forms an anastomotic arch with the infra-orbital branch of the internal maxillary.

Branches arising on the inner side of the optic nerve. The *ethmoidal arteries* are two, viz. the anterior and the posterior. The posterior ethmoidal (*e*) is given off the first from the ophthalmic, and is sometimes as large as the continuation of that artery: at other times merely a trace of it exists. It runs from without inwards, passes through the posterior internal orbital canal to reach the ethmoidal groove within the cranium, and then divides into a *meningeal* and a *nasal* branch. The meningeal ramifies in the dura mater, particularly in the falx cerebri; the nasal branch enters the nasal fossa, through the foramina of the cribriform plate, and anastomoses with the ultimate divisions of the spheno-palatine artery.

The *anterior ethmoidal* (*f*) is inversely proportioned as regards size to the posterior artery, which is sometimes replaced by it; it enters the cranium through the anterior internal orbital canal, and divides into a *meningeal branch* distributed upon the falx cerebri, and a *nasal branch* which penetrates the olfactory cavities by the foramina of the cribriform plate. The branches to the falx are remarkably tortuous.

The *palpebral arteries* are divided into the *superior* and the *inferior*. Both arise from the ophthalmic opposite the cartilaginous pulley of the superior oblique. Sometimes they arise by a common trunk. Most commonly the inferior palpebral is given off a little before the superior. Sometimes the superior is so large, that it appears to result from a division of the ophthalmic itself into two equal branches.

The *inferior palpebral* passes vertically downwards, behind the tendon of the orbicularis muscle, proceeds outwards to reach the lower eyelid, along the whole length of which it runs in the form of an arch without any winding, and is gradually lost at the external canthus or angle of the eyelids.

The vascular arch thus formed, the *inferior palpebral*, is situated between the muscular fibres of the eyelid and the tarsal cartilage, immediately below the free border of that cartilage.

At the point where it enters the eyelid, it gives off a very remarkable branch, which anastomoses with the orbital branch of the infra-orbital artery. From the arch of anastomosis a branch arises, which enters the nasal duct (*branch of the nasal duct*), and ramifies in the mucous membrane of that passage, as far as the inferior meatus.

The *superior palpebral* passes downwards behind the orbicularis palpebrarum, and having reached the superior punctum lachrymale, is reflected outwards, between the muscular fibres and the tarsal cartilage, immediately above its free border, along which it forms an arch, and terminates by anastomosing with a palpebral branch derived from the superficial temporal.

Terminal branches of the ophthalmic. At the anterior extremity of the angle formed by the upper and internal walls of the orbit, the ophthalmic artery terminates by dividing into a *nasal* and a *frontal* branch.

The *nasal branch* varies in size, and is often larger than the ophthalmic artery itself, so that some anatomists have regarded it as a branch of the facial, with which it always anastomoses. It emerges from the orbit above the tendon of the orbicularis, and having given off a small branch which afterwards enters the groove in the os unguis, to be distributed to the mucous membrane of the lachrymal sac, it divides into two branches — one, named the

angular artery, runs in the groove formed by the nose and cheek, between the pyramidalis nasi and the levator labii superioris alæque nasi; it is accompanied by the vein, which lies to its outer side, and it is continuous with the facial artery, without any line of demarcation, the two vessels inosculating so completely, that it is impossible to define their respective limits: the other branch, the *dorsal* artery of the nose, runs along the dorsum of the nose, and terminates opposite each ala by anastomosing with its corresponding artery. These two divisions of the nasal branch of the ophthalmic are subcutaneous, and give off numerous ramifications, which cover the whole surface of the nose.

The *frontal branch* is smaller than the nasal, and generally smaller than the supra-orbital or superciliary; it passes upwards upon the forehead, parallel to the supra-orbital, with which it communicates above by a transverse branch; it divides into subcutaneous twigs, situated between the skin and the muscles, and into muscular and periosteal twigs.

Summary of the distribution of the ophthalmic artery. The ophthalmic sends branches to the ball of the eye, to its appendages, viz. the muscles, eyelids, and lachrymal apparatus, to the frontal region, and to the nose and nasal fossæ.

To the ball of the eye it gives the arteria centralis retinæ, which supplies the retina, the hyaloid membrane, and the capsule of the crystalline lens; the posterior, middle, and anterior ciliary arteries, which are distributed to the choroid membrane, the ciliary processes, and the iris.

It supplies proper muscular branches, and also twigs from its other branches, to the muscles of the eye.

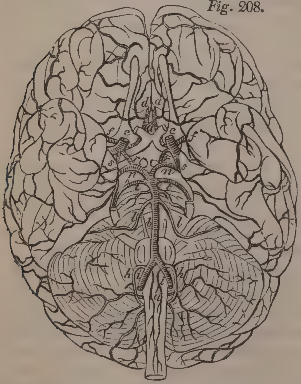
To the eyelids it gives off the palpebral arteries. To the lachrymal apparatus it supplies the lachrymal artery for the gland, and the two branches for the lachrymal sac and the nasal duct.

The frontal region receives its frontal and supra-orbital branches; the nose, the nasal branch, and the nasal fossæ, the anterior and posterior ethmoidal arteries.

The Cerebral Branches of the Internal Carotid Artery.

When the internal carotid has given off the ophthalmic artery, it enters (*c*, *fig.* 208.) a deep fossa seen on the base of the brain at the inner end of the fissure of Sylvius, and immediately divides into three branches, which spread out from each other.

Fig. 208.



Of these three branches, the anterior is called the *anterior cerebral*, or *artery of the corpus callosum*, the external is named the *middle cerebral*, or *artery of the fissure of Sylvius*, and the third or posterior is the *posterior communicating artery.*

Not unfrequently the carotid gives origin to the posterior cerebral artery, from which, in that case, the posterior communicating artery is then given off, and immediately joins the anterior extremity of the basilar artery.

The anterior cerebral artery. This vessel (*d d*, *fig.* 208.), also called the *artery of the corpus callosum*, passes immediately after its origin, forwards and inwards, towards the median line, and thus reaches the longitudinal fissure between the right and left anterior lobes of the brain. There it approaches its fellow of the opposite side, and communicates with it

by a transverse branch, which passes at right angles between them. This anastomotic branch (a), so remarkable for its size, shortness, and direction, is called the *anterior communicating artery;* instead of one, there are sometimes two smaller branches; sometimes it is so short, that the two anterior cerebral arteries may be said to be applied to each other, and blended together at this point: most commonly it is from one to two lines in length, and it then gives off some small twigs, which penetrate into the third ventricle.

After communicating in this manner, the anterior cerebral arteries become parallel, run from behind forwards, turn upwards in front of the anterior extremity of the corpus callosum, and then run backwards upon its upper surface, as far as its posterior extremity, describing a curve, which exactly corresponds with that of the corpus callosum itself.

Before turning over the anterior border of the corpus callosum, the anterior cerebral arteries give off some ramusculi to the optic and olfactory nerves, to the third ventricle, and the adjacent part of the anterior lobe of the brain, and also a series of large branches, which are distributed to the inferior surface of the same lobe. At the point where the arteries are reflected, and also along the upper surface of the corpus callosum, large branches arise from the convexity of the curve described by these vessels, and ramify upon the inner surface of the two hemispheres: the anterior branches run from behind forwards, and the others from before backwards, and from below upwards; most of them reach the convex surface of the brain. Some capillary twigs proceed from the concavity of the curve, and penetrate the substance of the corpus callosum.

We may regard as the termination of each anterior cerebral artery a very small branch which continues in the same course, reaches the posterior extremity of the corpus callosum, is there reflected downwards, and terminates in the adjacent convolutions of the brain.

The middle cerebral artery. This is larger than the preceding vessel; it passes (*f, fig.* 208.) outwards and backwards to enter the fissure of Sylvius, having previously given off a great number of rather large branches, which run perpendicularly upwards into the very thin layer of cerebral substance, situated at the junction of the longitudinal fissure of the brain with the fissure of Sylvius.*

As soon as the middle cerebral artery has entered the fissure of Sylvius, it divides into three branches — an anterior, which is applied to the anterior lobe; a posterior, which lies upon the middle lobe; and a median branch, which corresponds to the small lobe that is concealed within the fissure: they all follow the direction of this fissure, and are concealed within it, but soon emerge so as to ramify upon the convolutions and anfractuosities of the brain, anastomosing with each other and with the branches of the anterior and posterior cerebral arteries.

It is of importance to remark, and this observation applies to all the cerebral arteries, that the arterial ramifications destined for the surface of the brain are extremely tortuous, that they dip into the anfractuosities, and cover the free borders and the two surfaces of the convolutions, between which they are situated; that they ramify very freely, and run a very extensive course; and that they do not divide gradually into smaller and smaller branches, but that bundles of very fine capillary vessels arise from every part of the circumference of vessels of a certain size, and immediately penetrate the cerebral substance.

The posterior communicating artery, or communicating artery of Willis. This artery varies exceedingly in size, being generally small, but sometimes forming the largest division of the internal carotid. It arises from the back of the carotid, runs from before backwards (r), and terminates in the posterior cerebral branch of the basilar artery. In certain cases, the communicating

* We shall see hereafter that this region of the brain belongs to the corpus striatum.

artery of Willis may be regarded as the chief origin of the posterior cerebral, which then seems to result from the union of this communicating artery with the anterior bifurcation of the basilar.

The choroid artery. A very small but constant branch (*s*) arises from the back of the internal carotid, on the outer side of the communicating artery of Willis. This is the *artery* of the *choroid plexus*, which passes backwards and outwards, along the optic tract, and consequently along the crus cerebri, to both of which it sends branches, and then enters the lateral ventricle at the anterior extremity of the great transverse fissure of the brain, gives twigs to the hippocampus major and corpus fimbriatum, and terminates in the choroid plexus.*

Summary of the Distribution of the common Carotid Arteries.

The common carotids are distributed to the head, and to the organs which occupy the front of the neck.

The *internal carotid* belongs exclusively to the brain, and to the organs of vision; and hence, doubtless, at least in part, arises that intimate relation between the condition of the brain and of the eye, which is expressed by the common saying, that the eye is the mirror of the soul.

Although the size of the internal carotid is almost always in proportion to that of the brain, yet this artery is not the only one by which that organ is supplied with blood. The vertebral artery, a large branch of the subclavian, completes the arterial system of the brain; and the fact of an artery, principally destined for the upper extremity, also sending a branch to the brain, proves that there is nothing peculiar in the quality of the blood transmitted to the encephalon.

We have already seen that the ophthalmic artery communicates by its nasal branch with the facial artery, and by its inferior palpebral branch with the infra-orbital branch of the internal maxillary. But the internal carotid has no direct communication with the external, unless when it gives origin to the ascending pharyngeal and the occipital arteries. I may remark, however, that some meningeal branches are given off by the internal carotid within the cavernous sinus.

The *external carotid* differs from the internal, in giving origin to a very great number of branches, which are distributed to the face, to the parietes of the cranium, to the organs of respiration, and, lastly, to the organs of digestion.

The *facial* branches may be divided into the superficial and the deep-seated.

The *superficial* arteries of the face are derived from many sources. The principal one is furnished by the facial or external maxillary; the others are the transverse artery, or transverse arteries of the face, coming from the temporal; the nasal, a descending branch of the ophthalmic; the buccal, masseteric, infra-orbital, and mental, all derived from the internal maxillary. The arteries of the right side communicate very freely and fully with those of the left; and on each side, branches from the different sources communicate as freely with each other; so that, in hæmorrhage from any of them the injured vessel must be tied on both sides of the wound. I may call attention to the abundance of arterial vessels in the face, and to the number and size of the muscular and cutaneous branches; this is evidently connected with the extreme susceptibility of the skin of this region, the existence of the *hair-bulbs*, and the action of the muscles in giving expression to the features.

The *deep* arteries of the face are principally derived from the internal maxillary. Thus, the spheno-palatine supplies the nasal fossæ: some branches of the infra-orbital enter the orbit. We shall afterwards allude to

* See vertebral artery (p. 708.), for the completion of the arterial system of the encephalon.

the branches which are furnished to the buccal cavity, and the zygomatic and spheno-maxillary fossæ. Lastly, the superficial and deep arteries of the face are united by numerous anastomoses.

The *first set of cranial branches*, derived from the external carotid, are the *arteries of the hairy scalp*, viz. the occipital, temporal, posterior auricular, supra-orbital, and frontal. With regard to these arteries, it is important to notice their large size, which is connected with the great vitality of the skin of the head, and with the existence of the bulbs of the hair; also, that they are extremely tortuous; and, lastly, that they are situated in the dense cellular tissue which connects the skin with the muscles and the epicranial aponeurosis.

Besides these, small branches are found upon the pericranium, under the muscles and epicranial aponeurosis: they are seen on the forehead, where they arise from the frontal and infra-orbital arteries, and also in the temporal region, where they are called the deep temporals; these branches are both periosteal and muscular.

The *second set* of branches to the cranial parietes are *arteries of the interior of the cranium*, viz. the meningeal, the chief of which is the middle meningeal, a branch of the internal maxillary: the others, or small meningeals, enter through most of the foramina at the base of the cranium. Among these latter we would mention the meningeal branches of the ascending pharyngeal artery and meningeal branches from the ethmoidal arteries, to which may be added some small twigs given off from the internal carotid, whilst inclosed in the cavernous sinus.

We may also refer the arteries of the organ of hearing to those of the cranial parietes. They are the posterior auricular and the anterior auricular, which are distributed to the pinna and to the external meatus; the tympanic, which passes through the fissure of Glasserus, and a small branch of the middle meningeal, which enters through the hiatus Fallopii.

The branches of the external carotid distributed to the organs of digestion belong to the following parts: —

To the organs of mastication, viz. the alveolar, the infra-orbital, and the inferior dental arteries, which go to the teeth and the jaws; the superior palatine, which supplies the roof of the palate; and, lastly, the deep temporal, the masseteric, and the pterygoid, which are distributed to the muscles of mastication. To the salivary organs: thus, the parotid receives its branches from the external carotid and the temporal; the submaxillary gland from the facial; and the sublingual gland from the sublingual branch of the lingual artery. To the velum palati and the tonsils we find the ascending or inferior palatine branch of the facial artery, the superior palatine branch of the internal maxillary, and the ascending pharyngeal. To the pharynx, the pharyngeal twigs from the superior thyroid, the ascending pharyngeal, the pterygo-palatine or superior pharyngeal, and the vidian from the internal maxillary, and the inferior palatine branch of the facial. To the œsophagus there are the descending œsophageal branches of the superior thyroid.

The branches given by the external carotid to the air passages are the superior and inferior laryngeal, from the superior thyroid artery, which is essentially distributed to the thyroid gland.

Artery of the Upper Extremity.

A single arterial trunk, called the *brachial trunk* (*Chaussier*), is destined for the upper extremity. On the left side it arises directly from the arch of the aorta, and on the right side from the innominate artery; it emerges from the thorax between the first rib and the clavicle, traverses the axilla, runs along the inner side of the arm, passes in front of the elbow joint, and divides into two branches, which supply the fore-arm and the hand.

As the brachial trunk has some highly important relations during its course,

and moreover furnishes a very great number of branches, it has been artificially divided, in order to facilitate its study: each of the divisions has received a particular name, according to the region through which it passes: thus the artery of the upper extremity is called successively the *subclavian*, the *axillary*, and the *humeral* artery; and its terminal divisions are named the *radial* and *ulnar arteries*.

The Brachio-cephalic Artery.

The *brachio-cephalic* or *innominate artery* (*arteria anonyma* of many authors, *e*, *fig.* 198.) is the common trunk of the right subclavian and right common carotid arteries, and has in turns been regarded as a portion of the carotid, and as a part of the subclavian. It arises from the aorta, at the point where that vessel changes its direction from vertical to horizontal. It is situated in front and to the right of the other arteries given off from the arch of the aorta. It is from one inch to fifteen lines in *length*. It is *directed* obliquely upwards and outwards.

Relations. *In front* of the innominate artery is the sternum, beyond the upper end of which the artery almost always projects, and from which it is separated by the left brachio-cephalic vein, by the remains of the thymus, and by the sternal attachments of the sterno-hyoid and sterno-thyroid muscles. *Behind*, it is in relation with the trachea, which it crosses obliquely; on the *outer* side, with the pleura and mediastinum, which separate it from the lungs; on its *inner* side is the left common carotid, from which it is separated by a triangular interval in which the trachea is seen.

From a knowledge of these relations, modern surgeons have succeeded in applying a ligature to the innominate artery. Its relations, however, vary in different individuals. In some cases almost the whole length of the vessel projects beyond the sternum; and it is then extremely accessible, either to accidental wounds, or to the surgeon in the application of a ligature. It has been thought that the presence of the innominate artery explains the predominance of the right over the left upper extremity; but this opinion is entirely unfounded.

The innominate artery gives off no collateral branch, except in those cases in which it affords origin to the thyroid artery of Neubauer.

The Right and Left Subclavian Arteries.

The *right* subclavian artery (*g*, *fig.* 198.; *f*, *fig.* 204.) arises from the innominate (*e*); the *left* subclavian (*g'*), from the arch of the aorta.

Varieties of origin. One very common variety is that in which the right subclavian arises below the left, from the posterior and inferior part of the arch of the aorta, from which it passes upwards and to the right side, generally behind the trachea and œsophagus, sometimes between the two, and rarely in front of the trachea.*

The precise termination of this artery is not well defined. By most authors it is said to end, and the vessel to take the name of *axillary* artery as it passes between the scaleni.† It appears to me more convenient to take the clavicle as indicating the respective limits of the two vessels. All above the clavicle, then, belongs to the subclavian, and all below it to the axillary artery.‡

From the difference, as to origin, between the right and left subclavians, they differ from each other remarkably in length, direction, and relations.

Differences in length. The right subclavian is shorter than the left by the

* [It rarely passes between the trachea and œsophagus; and it appears there is no record of its having been actually seen in front of the trachea (see *Quain on the Arteries*).]

† According to some authors, the artery changes its name as it emerges from between the scaleni; according to others, whilst it is yet between those muscles.

‡ [In this country, the subclavian artery is commonly described as extending a short distance *below* the clavicle, and terminating in the axillary artery, opposite the *lower* or *outer* border of the first rib.]

length of the innominate artery; and we should, moreover, bear in mind the slight difference in the height between the origin of the innominate and the left subclavian. The *difference in the size* of the two subclavian arteries requires no special notice.

Differences in direction. The right subclavian passes at first obliquely outwards and a little upwards, and then bends over the apex of the lung, describing a curve with the concavity looking downwards. The left subclavian passes vertically upwards before curving over the apex of the lung, opposite which it changes its direction abruptly, and becomes horizontal.

Differences in relations. In describing these we shall divide the subclavian artery into three portions: the *first*, extending from the origin of the artery to the scaleni muscles; the *second*, situated between the scaleni; and the *third*, extending from the scaleni to the clavicle. The relations of the right and left subclavians differ from each other only in the first of these portions.

The *first portion* (1, *fig.* 204.) *of the right* subclavian is in relation in front with the inner end of the clavicle, the sterno-clavicular articulation, the platysma, and the clavicular attachment of the sterno-mastoid muscle, with the sterno-hyoid and sterno-thyroid muscles, with the termination of the internal jugular and vertebral veins in the subclavian vein, and with the right pneumogastric and phrenic nerves; behind, with the recurrent laryngeal nerve and the transverse process of the seventh cervical vertebra; on the outer side, with the mediastinal pleura, which separates it from the lung. On the inner side, it is separated from the common carotid by a triangular interval.* It is surrounded by loose cellular tissue, a great number of lymphatic glands, and nervous loops formed by the great sympathetic.

The *first portion of the left* subclavian is in relation with the same parts, though to a somewhat different extent: thus, its relations with the left mediastinal pleura and lung are much more extensive. The subclavian vein crosses it at right angles, instead of being parallel to it; but the left pneumogastric and phrenic nerves run parallel to instead of crossing it. It is parallel to the left common carotid, instead of forming an angle with it; and instead of being near the clavicle, the left subclavian is close to the vertebral column, and rests on the longus colli, the inferior cervical ganglion of the sympathetic nerve, and the thoracic duct, which is there to its inner side.

The *second portion of both the right and left* subclavian arteries, situated between the scaleni, is in close relation below with the middle of the upper surface of the first rib, on which there is a corresponding depression behind the tubercle for the attachment of the anterior scalenus; above, with the two scaleni, which are in contact with each other above the vessel; behind, with the brachial plexus; in front, with the scalenus anticus, which separates the subclavian artery from the subclavian vein. This separation of the artery from the vein is one of the most important points in its history. †

The *third portion* of the subclavian, or that extending from the scaleni to the clavicle, corresponds to a triangular space, bounded in front by the sterno-mastoid and anterior scalenus, above by the omo-hyoid, and below by the clavicle: this space is named the lower or clavicular portion of the posterior triangle of the neck, which is bounded in front by the sterno-mastoid, behind by the trapezius, below by the clavicle. In front of, but somewhat lower than, the artery is the clavicle, that bone being separated from the vessel by the subclavian vein, which is here below and in contact with the artery, and by the subclavius muscle; behind and to the outside of the artery is the brachial plexus of nerves, which surrounds the vessel in the axilla; it is covered by the deep cervical fascia, the platysma, the superficial fascia, and

* [It has been observed by Professor R. Quain (*loc. cit.*), that the origin of the right subclavian is sometimes partially or completely covered by the right carotid, a process of the cervical fascia separating the two vessels.]

† [Professor Quain has seen, in a few cases, the artery perforating the anterior scalenus; and it has even been found by himself and others anterior to that muscle, and therefore in contact with the vein.]

the skin, and is crossed by the descending cutaneous branches of the cervical plexus, and obliquely by the supra-scapular artery and vein; below, it rests upon the first rib.

In consequence of these relations, the subclavian artery may be compressed, and the circulation of the upper extremity stopped by forcible depression of the clavicle; the subclavian may be easily felt, compressed, and tied above the clavicle; and lastly, it follows that the sharp fragments of a broken clavicle can wound the coats of the artery only after having transfixed the subclavius muscle and the subclavian vein.

This artery, moreover, presents individual varieties both in regard to its direction and relations; it usually rises slightly above the clavicle, but in persons with short necks and high shoulders it is situated deeply under the clavicle, while in those who have long necks and low shoulders it may even slightly raise up the platysma and the skin.

Collateral branches. The subclavian artery gives off certain collateral branches, which may be divided into the *superior*, *inferior*, and *external*. The superior are the *vertebral* and the *inferior thyroid;* the inferior are the *internal mammary* and the *superior intercostal;* the external are the *supra-scapular*, the *posterior scapular* or *transversalis colli*, and the *deep cervical.*

Besides these, the subclavian arteries sometimes give off, near their origin, pericardiac, thymic, and œsophageal branches; not unfrequently the left subclavian gives origin to the bronchial artery of that side.

The Vertebral Artery.

The *vertebral artery*, destined for the cerebro-spinal nervous centre, supplies more particularly the spinal cord, the pons Varolii, the cerebellum, and the posterior portion of the cerebrum. It is the first and largest branch of the subclavian, and in some subjects is about equal in size to the continuation of that vessel. A very great inequality in the size of the two vertebrals is rather frequently met with. Morgagni states, that he has seen the right vertebral four times as large as the left; I have seen the left vertebral represented by a very small twig.

The vertebral artery arises (2, *fig.* 204.) from the upper and back part of the subclavian, at the point where it curves over the apex of the lung; the left vertebral often arises directly from the arch of the aorta, between the common carotid and subclavian of the same side. The right vertebral has been found arising from the point at which the innominate divides into the right common carotid and right subclavian. It has also been seen arising by two trunks, both of which sometimes come from the subclavian; and at others one proceeds from that artery, and the other from the arch of the aorta.

Immediately after leaving the subclavian, the vertebral artery passes vertically upwards, and a little backwards, enters between the transverse processes of the sixth and seventh cervical vertebræ, in order to reach the foramen in the base of the transverse process of the sixth, ascends through the foramina in the transverse processes of the succeeding cervical vertebræ, describing some slight curves in passing from one to another. In order to gain the foramen in the axis, it forms a considerable vertical curve between the atlas and that bone; it then forms a second horizontal curve between the atlas and the occipital bone, perforates the posterior occipito-atloid ligament and dura mater, and enters the cranium by the foramen magnum. The right and left vertebral arteries turn round the sides of the medulla oblongata, between the hypoglossal and sub-occipital nerves, converge (*i i*, *fig.* 208.) in front of the medulla, and near the furrow which separates it from the pons Varolii, unite at an acute angle to form the *basilar artery* (*b*). The two remarkable curves described by the vertebral artery before it enters the cranium, are in accordance with those formed by the internal carotid within the carotid canal and cavernous sinus. I have seen the vertebral very tortuous at the lower part of

the neck, before it entered the covered way formed for it by the cervical transverse processes.

Not unfrequently the vertebral artery enters the canal of the transverse processes at the fifth cervical vertebra; it has occasionally been seen to enter at the fourth, third, and even at the second. It very rarely enters the foramen of the seventh cervical vertebra.

Relations. Before entering the foramen of the sixth cervical vertebra, the vertebral artery is situated deeply upon the spine, between the longus colli and the anterior scalenus, and behind the inferior thyroid artery. The thoracic duct is at first on the inner side, and then in front of the left vertebral artery. From the sixth cervical vertebra to the atlas, it is protected by the canal formed by the series of foramina in the transverse processes, and in the intervals between them by the inter-transversales muscles; it lies in front of the cervical nerves, but the sub-occipital nerve lies between it and the groove in the atlas. In the intervals between the axis and atlas, and between the atlas and occipital bone, it is in relation with the complexus and trachelo-mastoideus, and with the rectus capitis posticus major and obliquus superior. In the cranium, it is situated between the basilar surface of the occipital bone and the anterior surface of the medulla oblongata.

Collateral branches. In its course along the canal of the transverse processes, the vertebral artery gives off spinal branches, which enter the vertebral canal through the intervertebral foramina, and are distributed in the same manner as the spinal branches of the intercostal and lumbar arteries. Several of these branches, however, are derived from the ascending cervical artery, and from the prævertebral branches of the ascending pharyngeal. From the two curves formed by the vertebral artery arise a great number of small muscular branches, which are distributed to the deep muscles of the cervical region, and anastomose with branches of the occipital and deep cervical arteries. Among these, there is one, sometimes two, which enters the cranium through the foramen magnum, and is distributed to the dura mater lining the inferior occipital fossæ, and to the falx cerebelli: it is the *posterior meningeal artery* (rami meninges posteriores, *Haller*). Sœmmerring has pointed out a small meningeal branch, which enters the cranium with the first cervical or sub-occipital nerve, and which appears to me to be constant.

In the cranium, before uniting to form the basilar, the vertebral arteries give off the *posterior* and *anterior spinal arteries*, and the *inferior cerebellar.*

Spinal arteries. These are small branches, remarkable for being extremely slender, and for arising at an obtuse angle, so that they descend in a precisely opposite direction to the vertebral arteries, which ascend vertically; they are distinguished into the *anterior* and the *posterior* spinal artery. It is incorrect to regard them as continued down to the lower part of the spinal cord; they are so slender, that they can only supply a very small portion of the cord; in reality they are nothing more than the commencement of the spinal arteries, which are continued through the whole extent of the cord by means of branches given off from the cervical, dorsal, and lumbar arteries.

The *posterior spinal* artery arises from the vertebral whilst that vessel lies upon the side of the medulla oblongata, and sometimes from the inferior cerebellar artery; it passes in a tortuous manner inwards, and divides into an ascending branch, which terminates upon the sides of the fourth ventricle, and a descending tortuous branch, which winds along the sides of the posterior surface of the cord, and divides into two twigs, a small one situated before and a larger one placed behind the posterior roots of the spinal nerves; around each of these roots they form a network, and, by means of transverse branches, which are twisted on themselves and much interlaced, they communicate with the corresponding branches of the opposite side. Chaussier was therefore incorrect in giving the name of the *posterior median artery of the spine* to the two posterior spinal arteries. These small branches of the vertebral are soon

exhausted; they are continued on each side by branches of the cervical, dorsal, and lumbar spinal arteries, which run upwards along the posterior roots of the nerves, and having reached the sides of the cord, divide into ascending and descending branches, which anastomose with the neighbouring vessels, form a network around each pair of nerves, and communicate by tortuous transverse branches with the arteries of the opposite side.

The *anterior spinal* artery (*u*, *fig.* 208.), which is somewhat larger than the posterior, arises from the vertebral near the basilar, sometimes even from the basilar itself, or from the inferior cerebellar, passes almost vertically inwards and downwards, in front of the medulla oblongata, and anastomoses in the same manner as the vertebral with its fellow of the opposite side, so as to constitute a median trunk, which is correctly named the *anterior median artery* of the spine; it is situated beneath the pearly fibrous band found along the anterior median furrow, and is continued by branches from the cervical, dorsal, and lumbar arteries.

The anterior, or median spinal artery, therefore, results from the anastomoses of the two anterior spinal branches of the vertebral. In one case there was no artery on the left side, but the right was twice as large as usual. The vessel is of considerable size, until it has passed below the cervical enlargement of the cord, from which point down nearly to the dorsal enlargement it becomes exceedingly delicate; a little above the last-named enlargement it suddenly increases in size, again gradually diminishes as it approaches the lower end of the spinal cord, and becoming capillary, is prolonged down to the sacrum, together with the fibrous string in which the spinal cord terminates.

During its course, this artery receives lateral branches from the ascending cervical and the vertebral in the neck, and from the spinal branches of the intercostal and lumbar arteries in the back and loins. These branches penetrate the fibrous canal formed by the dura mater around each of the spinal nerves; become applied to the nervous ganglia, to which they supply branches; get intermixed with, and follow the course of, the corresponding nerves; send small twigs backwards to the posterior spinal arteries, and terminate in the anterior spinal trunk, at variable angles, similar to those at which the nerves are attached to the spinal cord.

The re-inforcing spinal branches are not nearly so numerous as the nerves. If the condition which I have observed in three subjects be constant, there are three in the cervical region, one or two in the contracted portion of the cord, and one only at the inferior enlargement. This last, which in one case was as large as the ophthalmic artery, reached the cord at a very acute angle; opposite the median line, it divided into two branches, one ascending and very small, the other descending, of considerable size, and forming the true continuation of the trunk.

From the anterior spinal arteries there proceed a great number of twigs, which pass backwards into the anterior median furrow, and from thence into the substance of each half of the corresponding portion of the cord; also some lateral branches, which ramify on the sides of the cord in the pia mater.

The inferior and posterior cerebellar arteries. These (*h h*) arise from the outer side of the vertebral, and sometimes from the basilar; they are of considerable size, and often differ in this respect on the two sides. Each of them soon turns round the medulla oblongata, pursuing a tortuous course, passes between the filaments of origin of the hypoglossal nerve, runs in front of the roots of the pneumogastric and glosso-pharyngeal nerves, crosses the restiform body, and reaches the back of the medulla oblongata on one side of the opening of the fourth ventricle; it then passes backwards, between the inferior vermiform process and lateral lobe of the cerebellum, and divides into two branches — one *internal*, which continues along the furrow between the vermiform process and lateral lobe, supplies the former, and turns upwards into the notch in the posterior margin of the cerebellum: the other branch is *external*, and passes outwards upon the lower surface of the cerebellum, and divides into a great

number of twigs, which may be traced as far as the circumference of the cerebellum, and which anastomose with those of the superior cerebellar artery.

The basilar trunk. The basilar trunk (*b*) results from the junction or confluence of the two vertebral arteries. It is larger than either of them singly, but its area is not equal to the sum of their areas; so that by this arrangement the passage of the blood is accelerated. It commences opposite the furrow between the medulla oblongata and the pons Varolii, and terminates by bifurcating in front of the anterior border of the pons; its length, therefore, corresponds to the antero-posterior diameter of the pons, on the median furrow of which it is situated. When the vertebral arteries are displaced towards the right side (a very common condition), the basilar trunk passes horizontally or obliquely to the left, so as to reach the median furrow.

It gives off no branch from its lower surface, which rests upon the basilar groove of the occipital bone. A great number of capillary twigs are detached from its upper surface, and enter the pons Varolii. From its sides proceed the *anterior inferior cerebellar* and the *superior cerebellar.*

The anterior and inferior cerebellar arteries (*l l*) vary much in size in different subjects, and are rarely equal in this respect on the right and left sides: each of them arises from about the middle of the basilar, and occasionally from the vertebral itself, passes outwards and backwards, sometimes behind, and sometimes in front of the sixth nerve, runs along the crus cerebelli, passes in front of the facial and auditory nerves, and terminates upon the anterior portion of the hemisphere of the cerebellum.

The *superior cerebellar arteries* (*t t*) arise one from each side of the basilar, immediately before it divides into its two terminal branches; they might, therefore, also be regarded as terminal branches of that artery, which would thus end by dividing into four branches. Having arisen at a right angle behind the third, or motor oculi nerve, each superior cerebellar artery, accompanied by the fourth or trochlear nerve, turns round the crus cerebri in the groove between it and the pons Varolii; and having reached the upper surface of the corresponding crus cerebelli, divides into two branches: one *external*, which passes outwards on the upper surface of the cerebellum, along the anterior half of its circumference; the other *internal*, which is directed inwards upon the sides of the superior vermiform process, or median lobule of the cerebellum, and then subdivides into an *antero-posterior* branch, which passes from before backwards upon the sides of the vermiform process, as far as the circumference of the cerebellum upon which it ramifies; and a *transverse* branch, which continues the original course of the vessel towards the median line, running between the superior vermiform process and the valve of Vieussens, and being distributed to both.

The terminal branches of the basilar trunk are *the posterior cerebral arteries* (*n n*); they arise at variable angles, are directed forwards and outwards, and then curve backwards, so as to turn round the crus cerebri, parallel to the superior cerebellar arteries, from which they are separated by the third or motor ocuii nerve. They follow the concave border of the great transverse fissure of the brain, and having reached the posterior extremity of the corpus callosum, leave this fissure to pass backwards upon the lower surface of the posterior lobe of the cerebrum, where they may be traced as far as the occipital region. Each of the posterior cerebral arteries gives off, immediately after its origin, an immense number of small parallel twigs, which enter the substance of the brain between the anterior crura, whence the name of perforated spot given to that portion of the brain. Just as each posterior cerebral artery curves backwards, it receives the communicating artery of Willis (*r*), which is sometimes very large, and at other times very small. When large, it evidently assists in the formation of the posterior cerebral, which, after its junction with the communicating artery, sometimes becomes doubled or trebled in size. The part performed by the internal carotid in the formation

of the posterior cerebral is therefore subject to variety. In certain cases, as I have already stated, the posterior cerebral is exclusively derived from it.

The *posterior choroid* artery arises from the back part of the posterior cerebral, immediately after the junction of that vessel with the communicating artery; it turns round the crus cerebri, passes above and supplies the tubercula quadrigemina, and terminates in the velum interpositum and choroid plexus.

As the posterior cerebral artery quits the crus cerebri, it gives off a branch which passes outwards and backwards, crosses obliquely the long convolution which forms the lateral boundary of the great fissure of the brain, and ramifies upon the lower surface of the cerebrum. Lastly, the posterior cerebral gives off a small constant branch, which may be called the artery of the *fascia dentata*, to which it is distributed.

Remarks on the Arteries of the Brain, Cerebellum, and Medulla Oblongata.

The arteries of the encephalon, *i. e.* of the brain, cerebellum, and medulla, are derived from four principal trunks, two anterior, viz. the internal carotids, which arise from the common carotids, and two posterior, viz. the vertebrals, which are branches of the subclavian arteries. There are several circumstances to be remarked concerning these vessels, viz. their great size, which is dependant on that of the brain; their depth from the surface before they enter the cranium; the numerous curves formed by them as they are entering the cranial cavity, the use of which is evidently to retard the course of the blood; the absence of any large collateral branches, the only exception being the ophthalmic branch of the internal carotid, by the existence of which the circulation in the eye is connected with that in the brain. Another remarkable point concerning these vessels is their anastomoses at the base of the cranium, viz. the anastomosis, or rather the confluence, of the right and left vertebral, so as to form the basilar artery; the anastomosis of the right and left internal carotids by means of the anterior communicating artery, which unites the anterior cerebrals, and the anastomosis of the internal carotids with the vertebrals by the communicating arteries of Willis. By these anastomoses an arterial hexagon (the circle of Willis) is formed, the anterior margins of which correspond with the anterior cerebral arteries, the posterior with the posterior cerebrals, and the lateral with the communicating arteries of Willis.*

From this hexagon, as from a centre, proceed all the arteries of the brain, viz. from the anterior angle, the anterior cerebral arteries; from the posterior angle, the basilar artery; from the anterior lateral angle on each side, the middle cerebral; and from the posterior lateral angle on each side, the posterior cerebral artery.

Owing to the existence of these large anastomotic communications, any one of the four arterial trunks would be sufficient to carry on the circulation in the brain, if the other three were wanting or obliterated. The situation of this arterial hexagon between the bones of the cranium and the brain is remarkable, because it explains the alternate movements of elevation and depression seen in the brain when that organ is exposed during life.

It should also be observed that the arteries of the cerebellum, pons Varolii, and medulla oblongata are derived from the same sources as those of the brain.

Lastly, as to the mode of distribution of these vessels it may be remarked, that the arteries of the brain pass over the free surface of one or more convolutions, dip into the sulci between the convolutions, are reflected from one side of them to the other, give off a great number of very small branches, emerge from a given sulcus to regain the surface of the adjacent convolutions,

* In a person who died of apoplexy, Morgagni found a want of communication between the vertebrals and carotids; and he attributed the apoplexy partly to this circumstance, and partly to the fact that the left vertebral arose directly from the arch of the aorta.

and so on until they are exhausted. The principal arteries of the cerebellum run upon its surface, without passing into the sulci between the laminæ, into which they send only very small branches. With some exceptions, the arteries are reduced to capillary dimensions before they enter the nervous substance.

The Inferior Thyroid Artery.

Dissection. Dissect the muscles of the sub-hyoid region; follow the branches of the thyroid; trace the divisions of the ascending cervical artery into the grooves upon the transverse processes of the cervical vertebræ, and into the vertebral canal.

The *inferior thyroid* artery (3, *fig.* 204.) arises from the front of the subclavian on a plane anterior to the vertebral, which often comes off exactly opposite to it. It varies remarkably in size and origin, as well as in the branches which it furnishes. It frequently arises from the common carotid, sometimes from the arch of the aorta, between the brachio-cephalic and the left common carotid; at other times from the brachio-cephalic itself. Lastly, it is occasionally replaced by the thyroid of Neubauer.

It often commences by a common trunk with the supra-scapular, less frequently with the posterior scapular, and rarely with the internal mammary.

Its size bears an inverse proportion to that of the superior thyroid of the same side, and depends also on the presence or absence of a third thyroid. It is larger in infancy than at any other period. In certain cases of goître it becomes prodigiously developed. Sometimes there is merely a trace of its existence, or it is even altogether wanting.

Immediately after its origin it passes vertically upwards, then descends so as to describe a curve with its concavity directed downwards; and again forms another curve with its concavity turned upwards, to reach the lower end of the lateral lobe of the thyroid gland, in the interior of which it ramifies.

Relations. Behind, it is in relation with the trachea, the œsophagus, and the vertebral column, being separated from the latter by the prævertebral muscles and the vertebral artery. Its relation with the œsophagus is more marked on the left, than on the right side, and it is important to bear this fact in mind in performing the operation of œsophogotomy. *In front*, its first curve embraces the common carotid, the internal jugular vein, the pneumogastric and the great sympathetic nerves. The middle cervical ganglion, when it exists, rests upon it. The second curve embraces the recurrent laryngeal nerve, and is also in relation with the muscles of the sub-hyoid region. It may be remarked that there is one point in the neck where three arteries come into contact, viz. the common carotid, the inferior thyroid, and the vertebral.

Collateral branches. The inferior thyroid gives off downwards an *œsophageal branch*, some *tracheal* branches, and a small *bronchial* twig. I have seen the right bronchial artery derived from it. It also gives off several muscular branches to the scalenus anticus and the prævertebral muscles. The most remarkable of all these is the *ascending cervical* artery (4), which is of variable size, and is sometimes so large that it may be regarded as resulting from the bifurcation of the inferior thyroid. It passes vertically upwards, in front of the scalenus anticus, then in the groove between it and the rectus capitis anticus major; to both of which, as well as to the attachments of the levator anguli scapulæ, it gives some small branches. The most remarkable of its branches, called the *cervico-spinal*, enter the grooves by which the cervical nerves emerge, run in front of these nerves, and anastomose with the branches of the vertebral artery. I have seen these branches divide into two ramusculi: the one anterior, very small, which passed in front of the vertebral artery, and emerged upon the sides of the body of the vertebra; the other posterior, which passed between the corresponding nerve and the artery, entered the spinal canal through the intervertebral foramen, and was distributed to the vertebræ,

and to the spinal cord and its membranes, in the same manner as the dorsal and lumbar spinal arteries. The prævertebral branch of the ascending pharyngeal artery sometimes supplies the cervico-spinal branch of the first two inter-vertebral spaces in the cervical region.

Terminal branches. Opposite the lower extremity of the lateral lobe of the thyroid gland, the inferior thyroid artery divides into three branches: of these, one follows the lower border of the gland, another passes to the posterior surface of its lateral lobe, whilst the third dips between the gland and the trachea, runs along the lower border of the cricoid cartilage, sometimes becomes superficial opposite the isthmus of the thyroid body, and forms an anastomotic arch with its fellow of the opposite side, along the upper margin of that isthmus.

The Supra-scapular Artery.

The *superior* or *supra-scapular artery* (*transversus humeri*, 5, *fig.* 204.), destined for the supra- and infra-spinous fossæ, and which might also be denominated the *cleido-supra-scapular* from its course, arises from the front of the subclavian below the inferior thyroid, and often by a common trunk, either with the posterior scapular, or with the inferior thyroid and posterior scapular united, forming what is then called the thyroid axis. It is at first directed vertically downwards, then bends horizontally outwards to run along behind the clavicle, and gain the upper border of the scapula, where it passes over, very rarely under, the ligament, which converts the coracoid or supra-scapular notch into a foramen; and being reflected over that ligament, dips into the supra-spinous fossa, and crossing the concave border of the spine of the scapula, enters the infra-spinous fossa, in which situation it terminates (5′, *fig.* 209.).

Relations. It is concealed at its origin by the sterno-mastoid muscle, and is then situated along the base of the supra-clavicular triangle; it is in relation *in front* with the clavicle, following the direction of that bone; *behind*, with the subclavian artery and the brachial plexus of nerves, which it crosses at right angles; *above*, with the deep fascia and the platysma myoides, which separate it from the skin; and *below*, with the subclavian vein: more externally, it dips under the trapezius, and comes in contact with the supra-scapular nerve, is separated from it at the coracoid notch, and again becomes applied to it in the supra- and infra-spinous fossæ, where it is situated between the muscles and the bone.

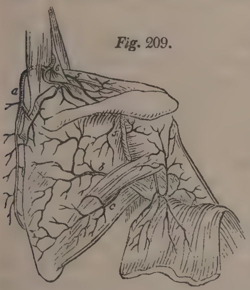
Collateral branches. Among a great number of unnamed muscular and cutaneous branches, I would particularly notice, 1. A small thoracic branch, which passes vertically downwards behind the clavicle, perforates the subclavius, and anastomoses with the thoracic arteries. 2. A branch for the trapezius, which is so large, that it appears to result from the bifurcation of the artery. It generally arises at the point where the vessel dips into the supra-spinous fossa; at other times it comes off very near the origin of the artery, passes from before backwards, turns round the scaleni muscles parallel with the posterior scapular artery, with which one might confound it, and ramifies in the trapezius and the supra-spinatus muscles, entering the former at its under, and the latter at its upper, surface: some of the branches are distributed to the periosteum of the acromion and to the corresponding integuments.

Again, in the supra- and infra-spinous fossæ it gives off a great number of periosteal, osseous, muscular, and articular branches. In the infra-spinous fossa (5, *fig.* 209.), it forms a free arched anastomosis with the subscapular artery, and gives off a branch which runs along the axillary border of the scapula, and anastomoses with the posterior scapular artery at the lower angle of that bone.

The Posterior Scapular Artery.

The *posterior scapular* (*transversus cervicis, transversalis colli*, 6, *fig.* 204. 209.) is larger than the preceding, and extends from the subclavian to the vertebral border of the scapula; it arises from the front of the subclavian, sometimes to the inner side of the scaleni, sometimes between them, but most commonly on the outer side of those muscles *: in the first case it often comes off by a common trunk with the inferior thyroid, and in the two other cases by a common trunk with the supra-scapular. It passes transversely and in a slightly tortuous manner outwards, through the nerves of the brachial plexus, and sometimes through the scalenus posticus, and curves backwards towards the posterior superior angle of the scapula. Then, opposite the levator anguli scapulæ, it divides into an *ascending* and a *descending* branch. The *ascending* or *cervical* branch, the *superficial cervical* artery of authors, passes beneath the trapezius, and divides into a great number of twigs, which ramify in that muscle, in the levator anguli scapulæ, and in the splenius. The *descending* branch forms the posterior *scapular* artery properly so called (*a*, *fig.* 209.), and may be regarded as the continuation of the vessel; it turns round the posterior superior angle of the scapula, beneath the levator anguli, passes vertically downwards along the vertebral border of that bone, and terminates at the inferior angle by anastomosing with the subscapular artery, a branch of the axillary, and with the suprascapular, already described.

Fig. 209.



Relations. It is superficial in the first part of its course, during which it traverses the supraclavicular triangle horizontally, being merely covered by the cervical fascia, the platysma myoides, and the omo-hyoid; and hence, doubtless, the name *superficial cervical*, which has been given to it by some authors. † It is but rarely that the posterior scapular turns round the posterior scalenus and the brachial plexus, without passing between the nerves of the plexus, which it traverses at variable heights. As it proceeds backwards, it is protected by the trapezius; and lastly, along the vertebral border of the scapula, it lies between the rhomboideus and the serratus magnus.

Its *collateral branches* are destined for the following muscles — the trapezius, scalenus posticus, levator anguli scapulæ, splenius, supra- and infra-spinati, subscapularis, rhomboideus, and serratus magnus.

The Internal Mammary Artery.

The *internal mammary*, or internal thoracic, artery, not so remarkable for its size, which is less than that of the vertebral, as for its length and the number of its branches, arises (7, *fig.* 204.) from the subclavian opposite the inferior thyroid, and behind the supra-scapular. Few arteries are less variable in their origin. The only varieties which have been observed are those in which it arises from the brachio-cephalic, from the arch of the aorta, or from a common trunk with the inferior thyroid. Immediately after its origin, it passes vertically downwards behind the inner end of the clavicle, enters the thorax, crosses obliquely behind the cartilage of the first rib, and bends a little inwards to run along the first portion of the sternum, below which

* In the last case, those authors who describe the subclavian as terminating between the scaleni, say that the posterior scapular arises from the axillary artery.

† [It is the ascending or cervical branch only that is named *superficial* cervical.]

it resumes its vertical direction, parallel to the border of that bone, as low down as the sixth rib, where it divides into an internal and an external branch.

Relations. It is situated in front of the scalenus anticus, and is covered at its origin by the phrenic nerve, which crosses it very obliquely, in order to reach its inner side; it corresponds to the inner end of the clavicle, from which it is separated by the brachio-cephalic vein; it is then placed behind the costal cartilages and the intercostal muscles, in front of the pleura, from which it is separated by the triangularis sterni. It is situated about two lines to the outer side of the margin of the sternum, so that a cutting instrument may be carried into the thorax along that bone without injuring the internal mammary; the name substernal is, therefore, not at all applicable to this artery, which would be better named *sub-chondro-costal.*

Collateral branches. These are very numerous; they may be divided into the *posterior*, *anterior*, and *external.* The *posterior branches* are, the *thymic* or *anterior mediastinals*, and, lower down, the *superior phrenic*, an extremely small artery, which runs along the phrenic nerve, is situated, like it, between the pericardium and the corresponding layer of the mediastinum, and reaches and is ramified in the diaphragm. Bichat has seen the superior phrenic artery as large as the internal mammary itself.

The *external branches* are the *anterior intercostals.* Their number corresponds with that of the intercostal spaces: they are small in the first two, and gradually increase or diminish according to the length of the corresponding spaces. I have seen the common trunk for the third intercostal space so large, that it appeared like a bifurcation of the mammary. There are generally two branches for each intercostal space: one, which runs along the lower margin of the rib above, and the other along the upper margin of the rib below. These two branches sometimes arise separately from the mammary, sometimes by a common trunk; as they arise above the level of the space for which they are intended, it follows that they pass obliquely behind the costal cartilages. The anterior intercostals inosculate with the aortic or posterior intercostals, so that it is sometimes impossible to determine the limits between these two sets of vessels. In some subjects they form a communicating arch of uniform caliber, extending between the internal mammary and the thoracic aorta.

The *anterior branches* are superficial, and correspond in number to the intercostal spaces; they arise from the internal mammary, pass directly from behind forwards, through the corresponding intercostal space, and divide into *cutaneous* and *muscular branches*, both of which sets curve outwards, the muscular branches beneath the pectoralis major, in which they ramify, and the cutaneous branches beneath the skin. The anterior branches of the first three spaces are distributed to the *mammary gland.* In females recently delivered, and in nurses, these branches become extremely large, especially the second, which I have seen as large as the radial artery, and very tortuous. Before perforating the intercostal muscles, the anterior branches send some periosteal twigs behind the sternum, some of which penetrate the bone directly, whilst others ramify on the periosteum.

Terminal branches. Of the two terminal branches, the *internal*, and smaller, continues the original course of the artery, passes behind the rectus abdominis muscle, enters its sheath, and then divides into a great number of branches; some of these are lost in this muscle by anastomosing with the capillary divisions of the epigastric, while the others emerge from the sheath of the rectus by special openings, and are distributed to the broad muscles of the abdomen, and to the integuments. Before leaving the cartilage of the seventh rib, it gives off a small twig, which passes inwards upon the side of the ensiform cartilage, and forms an anastomotic arch with its fellow of the opposite side, in front of that cartilage. The anastomosis of this artery with the epigastric, which has been known from the very earliest periods, and afforded the ancients an explanation of the intimate physiological connections between the genital

organs and mammary glands, is accomplished in the usual manner of capillary communication.

The *external terminal branch*, as far as distribution is concerned, is the continuation of the internal mammary. It is directed downwards and outwards, behind the cartilages of the seventh, eighth, ninth, tenth, and eleventh ribs, which it crosses obliquely, and terminates opposite the last intercostal space. During its course, it gives off the *anterior intercostals* of the corresponding spaces, two for each space, sometimes only one, which immediately subdivides. These intercostals diminish gradually in size as the spaces decrease in length, and are distributed precisely as the anterior intercostal branches of the internal mammary itself. The external terminal branch, and also the internal, whilst passing through the diaphragm near its costal attachments, give off a great number of branches to that muscle, and hence the name *musculo-phrenic*, given by Haller to the external division, which, indeed, furnishes many more branches to the diaphragm than the internal.

The deep Cervical Artery.

Dissection. Seek at first for the artery behind the scalenus anticus, between the transverse process of the seventh cervical vertebra and the first rib; trace it, both to its termination between the complexus and semi-spinalis colli, and towards its origin within the scaleni.

The *posterior*, or *deep cervical*, comes off deeply from the upper and back part of the subclavian, on the same plane as the vertebral, to the outside of which it is situated. Very often it arises by a common trunk with the first intercostal. It passes at first upwards and backwards, then bends outwards behind the scalenus anticus to dip between the transverse process of the seventh cervical vertebra and the first rib. I have never seen it pass between the transverse processes of the sixth and seventh cervical vertebræ, though for this purpose I have examined forty subjects.*

After leaving the inter-transverse space, the deep cervical artery divides into two branches, —one *descending*, which I have been able to trace as far as the middle of the dorsal region, between the long muscles of the back; the other *ascending*, which passes up between the complexus and the semi-spinalis colli, in which it terminates, and anastomoses with the occipital and vertebral arteries.

The Superior Intercostal Arteries.

Dissection. This artery can only be dissected from the internal surface of the thorax. For this purpose it is necessary to saw through the thorax vertically. The artery must be exposed by removing the pleura from the two upper ribs and intercostal muscles.

The *superior intercostal* artery, intended for the two or three superior intercostal spaces, sometimes only for the first, varies in size according to the extent of its distribution. It comes off from the lower and back part of the subclavian, near the deep cervical, and sometimes by a common trunk with it. It descends in a tortuous manner in front of the neck of the first, and then of the second rib, on the outside of the first dorsal ganglion of the sympathetic nerve, and terminates in the second intercostal space, like an aortic intercostal artery; sometimes it anastomoses freely with the first of the aortic intercostals. It gives off in each space a *dorso-spinal branch*, and an *intercostal branch* pro-

* This relation is so constant, that even in cases where there is a supernumerary cervical rib, the deep cervical artery passes between this supernumerary rib and the first dorsal rib. Some students having called me to examine a subject in which this artery was wanting, I sought in vain for it between the first rib and the transverse process of the last cervical vertebra, and then perceived that there was a cervical rib, between which and the first dorsal rib the artery was found.

[In 264 observations, Professor Quain met with this variety in the course of the artery four times, and also other peculiarities.]

perly so called. It is not rare to find the intercostal branch wanting in the first space: in all cases it is extremely small.

The Axillary Artery.

Dissection. In order to prepare the axillary, as well as all the other arteries of the upper extremity, it is sufficient to dissect the muscles carefully, at the same time preserving all the branches which are met with, and tracing them to their origin.

Fig. 210.

The *axillary artery* (*a a'*, *fig.* 210.) is that part of the artery of the upper extremity which intervenes between the subclavian and the brachial. Its limits, which are entirely artificial, are the clavicle* on the one hand, and the lower border of the pectoralis major on the other. It traverses the axilla diagonally, and bends opposite the neck of the humerus, so as to become continuous with the brachial artery. Its upper part rests upon the thorax, and its lower upon the humerus; it is not very tortuous, so that in forcible abduction of the arm it may be stretched even to laceration. Its direction corresponds pretty nearly with the cellular interval so generally existing between the sternal and the clavicular portions of the pectoralis major, or rather with an imaginary line extending from the junction of the outer with the two inner thirds of the clavicle to the inner side of the neck of the humerus.

Relations. From the importance necessarily attached to an accurate knowledge of the relations of this artery, we shall consider them in the four aspects of the vessel.

In front, the axillary artery is in relation from above downwards with the subclavius muscle, a process of the deep cervical fascia intervening between them; then with the costo-coracoid ligament and the pectoralis major; next with the pectoralis minor; below this muscle with the pectoralis major again; and, lastly, with the coraco-brachialis. *Behind*, it is in relation with the cellular interval between the subscapularis and serratus magnus; lower down with the teres major and latissimus dorsi. *On the inside*, it rests at first upon the first rib and the first intercostal space; it next leaves the thorax, from which it is separated by the hollow of the armpit, and its inner side is then in relation with the skin which forms the outer wall of the armpit, and with the subjacent fascia. *On the*

* Those authors who consider the subclavian as terminating between the scaleni, describe the axillary as commencing at the same point.

[The axillary artery is commonly said in this country to commence at the lower border of the first rib (*a*), and to terminate at the lower border of the conjoined tendons (*a'*) of the latissimus dorsi and teres major muscles.]

outside, it is at first embraced by the concave surface of the coracoid process, and it is then placed opposite the head of the humerus, from which it is separated by the subscapularis muscle.

Relations with the axillary vein and nerves. Immediately below the clavicle, the axillary vein is situated on the inner side of, and at some distance from, the artery; lower down, the vein lies upon the artery. The cephalic and acromial veins pass in front of the artery.

Immediately below the clavicle, the entire brachial plexus is situated on the outer side of the artery, only one thoracic nerve crossing in front of it. Under the pectoralis minor the artery is surrounded by the plexus; it is at first embraced by the external and internal roots of the median nerve, which meet in the form of a V opening upwards; lower down, it is placed between the external cutaneous nerve on the outer side, the median in front, the internal cutaneous and the ulnar on its inner side, and the radial, or musculo-spiral, and the circumflex behind. In order to expose the artery in the axilla, the vessel may be sought for between the median and ulnar nerves.

In consequence of these relations, wounds of the axilla may be very serious; compression may be applied to the axillary artery, either by forcibly depressing the clavicle against the first intercostal space and second rib, or by placing the finger upon the vessel in the axilla, and pressing it against the head of the humerus; a ligature may be applied to this artery, either under the clavicle above the pectoralis minor, or in the axilla; lastly, the artery may be torn from extreme violence in attempting to reduce a dislocation.*

Collateral branches. The axillary gives off five branches, viz. the *acromio-thoracic*, above the pectoralis minor; the *inferior thoracic*, or *external mammary*, below the pectoralis minor; the *inferior scapular*, and the anterior and posterior circumflex arteries, opposite the neck of the humerus.

The Acromial and Superior Thoracic Arteries.

Under the name of *acromio-thoracic* I include two arteries, the *acromial* and the *superior thoracic*, which almost always arise by a common trunk, which is detached at right angles from the inner side of the axillary artery immediately above the pectoralis minor, then crosses the upper border of that muscle at right angles, and immediately divides into the two above-named branches.

The *thoracic branch* passes downwards and inwards, and subdivides (*b b*) between the two pectoral muscles, both of which it supplies, but especially the lesser. Some branches perforate the pectoralis major, and are distributed to the skin and the mamma.

The *acromial branch* subdivides into two others — a *descending* or *deltoid* branch (*c*), which enters the cellular interval between the pectoralis major and the deltoid, traverses it throughout, and is distributed to these two muscles, but especially to the deltoid; it is accompanied by the cephalic vein: the second is a *transverse* or *acromial* branch (*d*), which runs horizontally outwards, passes over the apex, and sometimes over the base of the coracoid process, then upon the coraco-acromial ligament, and runs along the outer third of the anterior border of the clavicle. It is covered in the whole of its course by the deltoid, to which it is in a great measure distributed. Some twigs terminate in the skin over the acromion. This acromial branch terminates near the acromio-clavicular articulation; sometimes one of its divisions closely follows the anterior border of the clavicle.

The Inferior or long Thoracic Artery.

The *inferior thoracic*, *long thoracic*, or *external mammary* artery (*e*, *fig.* 210.), is much larger than the acromial thoracic, and sometimes arises by a common

* I have seen two cases of rupture of the axillary artery from attempts to reduce old dislocations.

trunk with it or with the sub-scapular; it is given off from the axillary below the pectoralis minor, passes downwards and forwards upon the side of the thorax, between the pectoralis major and serratus magnus, then between the serratus and the skin, and terminates at about the sixth intercostal space. During this course it gives off a great number of branches * to the lymphatic glands in the axilla, to the sub-scapularis, pectoralis major, and serratus magnus muscles, to the second, third, fourth, fifth, and sixth intercostal spaces, to the mamma, and to the skin. Not unfrequently the inferior thoracic partially supplies the place of the sub-scapular artery, in which case it is as large as that vessel.

The Subscapular Artery.

The *inferior, common, or sub-scapular* artery (*f*), the largest branch of the axillary, arises near the lower part of the head of the humerus opposite the lower border of the sub-scapular muscle, sometimes by itself, sometimes by a common trunk with the posterior circumflex, the long thoracic, or the deep humeral artery; in the last case it is as large as, perhaps even larger than, the brachial. At its origin, which is from the outer aspect of the axillary, it has the musculo-spiral nerve to its inner side, and the principal origin of the median on its outer side; it passes in a tortuous manner downwards and outwards along the lower border of the sub-scapularis muscle, parallel with the teres major, and beneath the head of the humerus †, furnishes large branches to all these muscles, and having arrived below the insertion of the sub-scapularis, divides into two branches, a *descending* or *thoracic*, and a *scapular*, properly so called.

The *descending* or *thoracic branch* (*g*), which is often given off by the inferior or long thoracic, passes downwards and forwards near the axillary border of the scapula, parallel with and behind the long thoracic, and divides into a great number of large branches, some of which enter the latissimus dorsi, several penetrate the serratus magnus even as far as the lowest portion of that muscle, whilst others turn round the lower angle of the scapula, and anastomose with the following or scapular branch, and with the posterior scapular derived from the subclavian.

The *scapular branch* (*i*), properly so called, proceeds along the lower border of the sub-scapularis muscle, in front of the long head of the triceps, and having reached below the scapular attachment of the triceps divides into three branches: an *anterior* or *sub-scapular branch*, which dips into the sub-scapular fossa below the muscle and expands into a great number of branches, the highest of which are distributed to the capsule of the shoulder joint; an *infra-spinous branch* (*b*, *fig.* 209.) which turns round the axillary border of the scapula, runs between the muscle and the infra-spinous fossa, and anastomoses, by a considerable branch, with the termination of the supra-scapular artery; a *median branch* (*c*, *fig.* 209.), which continues in the original course of the vessel, runs along the axillary border of the scapula, between the teres major and minor, then becomes posterior, and terminates by anastomosing again upon the lower angle of the scapula with the thoracic branch of this artery and with the infra-spinous branches of the supra-scapular.

* [These branches represent the *alar thoracic* artery, and sometimes arise directly from the axillary, behind the pectoralis minor, or from the sub-scapular.]

† The relation of the sub-scapular artery to the head of the humerus appears to me to be important. In abduction this artery is much stretched, and I am surprised that it has not been torn in some cases of luxation; on the contrary, the circumflex artery, and, therefore, the circumflex nerve, appear to me to be much less liable to be stretched during abduction. Nevertheless, it is certain that the circumflex nerve has been lacerated in some dislocations of the humerus, because they have been followed by paralysis of the deltoid muscle.

The Posterior Circumflex Artery.

The *posterior circumflex* artery (*l*, *fig.* 210.) arises from the back of the axillary opposite the sub-scapular, which it sometimes equals in size. It passes horizontally backwards, between the sub-scapularis above and the teres major below, turns inwards round the surgical neck of the humerus, passing first between the internal head of the triceps and the teres minor, then between the long head of the triceps and the bone, and finally (*l*, *fig.* 209.) under the deltoid, to the deep surface of which it is applied; it always turns round, so as to describe three fourths of a circle, and thus reaches the anterior and outer aspect of the humerus, and is lost in the deltoid by anastomosing with the deltoid branches of the acromio-thoracic artery. In the whole of its course it is accompanied by the circumflex vein and the circumflex nerve. As it turns round the bone, the posterior circumflex gives off some articular and periosteal branches, which pass to the capsular ligament of the shoulder joint, and to the periosteum of the humerus.

The Anterior Circumflex Artery.

The *anterior circumflex*, a small artery (*n*, *fig.* 210.), sometimes represented by several branches, arises from the axillary in front of the posterior circumflex, and often by a common trunk with it. It passes horizontally outwards above the conjoined tendons of the latissimus dorsi and teres major covered by the coraco-brachialis and the short head of the biceps, runs beneath the tendon of the long head of the biceps, turns round the neck of the humerus, crosses the bicipital groove at right angles, being held down by the synovial membrane, and divides into an *ascending* and a *descending* branch. The latter presents nothing remarkable; but the ascending branch, having reached the upper part of the groove, anastomoses with the osseous branch of the acromial artery, and is lost in the head of the humerus, which it penetrates at one or more points. The anterior circumflex is therefore intended for the humerus, its periosteum, and the synovial membrane of the groove. Sometimes there are several anterior circumflex arteries, which enter the substance of the deltoid muscle.

The Brachial Artery.

The *brachial* or *humeral artery* (*a' h*, *fig.* 210.), is that portion of the artery of the upper extremity which extends from the lower border of the axilla to the point of its bifurcation at the upper part of the fore-arm. It passes downwards, and a little forwards and outwards, so that it is situated on the inner side of the humerus above, and in front of it below. The absence of any bendings in this artery explains the possibility of its being torn from extreme extension of the fore-arm in dislocations of the elbow, &c.

The relations of the brachial artery require to be examined separately along the arm, and in front of the elbow joint.

Along the arm, the artery is in relation, *in front*, with the coraco-brachialis and the inner margin of the biceps, which may be regarded as the satellite muscle of the artery: in emaciated subjects the biceps does not cover the artery, which is then situated immediately under the fascia; *behind*, it is in relation with the triceps, and then with the brachialis anticus; *on the inner side*, with the fascia of the arm, which separates it from the skin; *on the outer side*, with the coraco-brachialis, then with the inner side of the humerus, from which it is separated by the tendon of the coraco-brachialis, and in the rest of its extent with the cellular interval between the biceps and the brachialis anticus. The brachial artery is inclosed in a fibrous sheath, which is common to it and the median nerve. The following are its relations with the veins and nerves: the principal brachial vein is situated on its inner side; another smaller

vein is on its outer side: both are in contact with the artery, which they separate from the nerves, and they are connected by several transverse branches, which embrace the artery.

The median nerve is situated in front of the artery, excepting above, where it is on its outer side, and below, near the elbow, where it passes to its inner side; the median nerve sometimes crosses behind the artery. The ulnar nerve is placed on the inner side of the artery above, then passes behind it, and is lodged in a separate sheath. The musculo-spiral nerve is situated, together with the deep humeral artery, at first behind the brachial, but soon leaves it to turn round the humerus; lastly, the internal cutaneous follows the same course as the vessel, crossing it slightly from before backwards.

From these relations it follows, that the vessel may be most efficaciously compressed from within outwards, against the inner surface of the humerus, and also that it may be tied in any part of its course.

At the bend of the elbow, the brachial artery occupies the middle of the articulation; it is superficial *in front*, where it is only separated from the skin by the fascia and tendinous expansion of the biceps, and by the median basilic vein, which crosses it at a very acute angle; *behind*, it rests upon the brachialis anticus, by which it is separated from the elbow joint; *on its inner side* is the median nerve and pronator teres muscle, and *on its outside*, the tendon of the biceps, over which it soon crosses, and further outwards the supinator longus.

In consequence of the superficial position of the brachial artery at the bend of the elbow, and from its relations with the median basilic vein and the elbow joint, it follows that this artery may be easily compressed, may be wounded in the operation of venesection, and may be lacerated in dislocations of the joint.

Collateral branches. These may be divided into the *external* and *anterior*, and the *internal* and *posterior.*

The *external and anterior* are very numerous, and are intended for the coraco-brachialis and biceps, which they penetrate at different heights, and also for the brachialis anticus. A very remarkable branch, which appears to me to be constant viz. the *deltoid*, passes transversely in front of the humerus, beneath the coraco-brachialis and the biceps, and terminates partly in the deltoid at its humeral insertion, and partly in the brachialis anticus. The *internal and posterior branches* are small, excepting those which enter the brachialis anticus directly: I have seen them all arise from the axillary by a large branch, given off from a common trunk with the sub-scapular and the posterior circumflex arteries.

Whatever may be their mode of origin, four of these collateral branches are remarkable for their regular distribution, viz. the *deep humeral*, the *internal collateral*, the *superficial branch for the internal portion of the triceps*, and the *superficial branch for the brachialis anticus.* The two former only have received particular names.

The *deep humeral* artery (*profunda superior*, *k*, *fig.* 210.), called also the *external collateral* from its terminating on the outer side of the articulation of the elbow, arises from the brachial, opposite the lower border of the teres major. It occasionally comes off by a common trunk with the posterior circumflex, which, in that case, arises from the brachial, instead of the axillary artery. It passes downwards and backwards, gains the groove for the musculo-spiral nerve, and traverses the whole extent of that groove together with the nerve. In this part of its course it is situated between the triceps muscle and the humerus, as it turns round the posterior surface of that bone; below the insertion of the deltoid it emerges from the groove, between the brachialis anticus and the triceps, and divides into a *deep* branch, which continues with the nerve, and a *superficial* branch. The former is distributed essentially to the triceps muscle, and sometimes comes off directly from the brachial; it passes vertically downwards in the substance of the triceps, supplies its internal and external portions, and terminates in them by anastomosing freely with the collateral branches situated around the elbow-joint. The *superficial* branch perforates

the external head of the triceps, and the external intermuscular septum, along which it descends vertically to the back of the epicondyle, or external condyle of the humerus, where it anastomoses with the interosseous recurrent artery.

The *internal* or *ulnar collateral* artery (*profunda inferior*, *m*, *figs.* 210, 211.) is much smaller than the external collateral, from which it is sometimes derived; it is often double. It usually arises at a variable height from the lower part of the brachial, sometimes passes transversely inwards, and sometimes proceeds in a tortuous manner downwards before becoming transverse, and then divides into two branches: one *anterior*, which is distributed to the brachialis anticus, the muscles attached to the epitrochlea or internal condyle of the humerus, and the periosteum upon that process; the other *posterior*, which perforates the internal intermuscular septum, and divides into muscular branches for the triceps; into periosteal and osseous branches, which pass transversely in front of the triceps, and anastomose with the interosseous recurrent; and into a descending branch, which accompanies the ulnar nerve, and anastomoses with the posterior ulnar recurrent.

The *superficial branch for the internal portion of the triceps* is remarkable for its size and length; it arises from the brachial, immediately below the profunda superior, from which also it is rather frequently derived, and passes vertically downwards applied to the ulnar nerve. It is at first situated in front of the internal intermuscular septum; then perforates it, accompanied by the ulnar nerve, and passing backwards between the epitrochlea and the olecranon, anastomoses with the posterior ulnar recurrent.

The *superficial branch for the brachialis anticus* arises from the brachial artery at the same height as the preceding, runs along the inner side of the brachialis anticus, gradually diminishing in size down to the lower part of the arm, where it anastomoses with the internal collateral artery.*

The *terminal branches* of the brachial are the *radial* (*p*, *fig.* 210, 211.) and *ulnar* (*g*) arteries. The bifurcation of the brachial artery into the radial and ulnar usually takes place below the bend of the elbow, sometimes on a level with it, but rather frequently above the articular line; in the latter case, the bifurcation has been observed to occur sometimes at the lower third or at the middle of the arm, sometimes at the junction of the upper with the two lower thirds, and sometimes in the axilla itself, the radial and ulnar arteries immediately succeeding to the axillary. In these cases one division of the artery, generally the radial, is subcutaneous, whilst the ulnar assumes the ordinary relations of the brachial; but the reverse of this may take place; and lastly, the radial and the ulnar have both been found subcutaneous. Not unfrequently the radial artery, at its origin, is the inner branch of the bifurcation, and then crosses the ulnar at a very acute angle in order to reach the radius. Besides these anomalies resulting from varieties in the point of bifurcation, there is yet another, in which a premature division takes place into two branches, one of which forms the interosseous artery, and the other the brachial, which has its usual arrangements; at other times, instead of a bifurcation, only a very slender branch is given off, and terminates in the ulnar, which in that case arises by two roots.

A knowledge of these anomalies, both in reference to the point of bifurcation and to the new relations of the parts, is extremely important to the surgeon.

The Radial Artery and its Branches.

Dissection. The radial artery in the fore-arm is completely exposed by dissecting the supinator longus; the carpal portion of the artery by dissecting the

* [These two superficial branches are frequently represented in their distribution by a single branch, called the *anastomotic artery* (*o*, *figs.* 210, 211.), which arises from the brachial about two inches above the elbow.

The *nutritious* artery of the humerus is small but constant; it arises from the outer side of the brachial, or one of its collateral branches, passes downwards, perforates the insertion of the coraco-brachialis muscle, and enters the oblique foramen in the inner side of the humerus, to ramify in the medullary canal of that bone.]

tendons of the thumb, opposite the wrist; the palmar portion by dividing all the flexor tendons in the palm. It is therefore advisable to postpone the examination of the palmar portion of the artery until the ulnar has been studied.

The *radial artery* (*p*, *figs*. 210, 211.), the outer of the two branches into which the brachial divides, is more superficial and smaller than the ulnar; it extends from the point of bifurcation of the brachial down to the palm of the hand. Sometimes the radial turns backwards, after having reached the lower third of the fore-arm, and remains subcutaneous until it dips between the first and second metacarpal bones; its place in front of the lower part of the radius is then supplied by the radio-palmar artery or superficialis volæ, which is extremely small. It is very common to find the radial artery of one arm larger than that of the other; in one case I found both radials wanting in front of the lower part of the radius.

The radial artery is at first directed downwards, and somewhat obliquely outwards, like the brachial, with the direction of which it corresponds; it then descends vertically as far as the lower end of the radius, turns round the anterior surface and apex of the styloid process, to gain the outer side of the carpus, and passes obliquely downwards and backwards to reach the upper part of the first interosseous space: there it turns abruptly forwards, between the upper extremities of the first and second metacarpal bones, passing between the two origins of the first dorsal interosseous muscle, enters the palm of the hand, and runs almost transversely inwards, to form the *deep palmar arch* (*b*, *fig*. 211.). The radial artery is frequently tortuous at the lower part of the fore-arm. From the long course and the direction of the radial, it may be divided into three portions, corresponding to the *fore-arm*, the *wrist*, and the *palm* of the hand.

The *first portion* of the radial artery, viz. that situated in the *fore-arm*, has the following relations: *in front*, with the inner border of the supinator longus, which overlaps it, especially above; in the rest of its extent it lies beneath the fascia. In emaciated subjects the supinator longus is narrow, and this part of the artery is sub-aponeurotic in its whole extent.

Behind, it corresponds to the anterior surface of the radius, from which it is separated above by the supinator brevis; lower down by the pronator teres, and by the radial origins of the flexor sublimis and flexor longus pollicis; still lower by the pronator quadratus, below which it rests directly upon the inferior portion of the radius. The superficial position of the radial artery, and the support afforded it by the bone, are the reasons why it is chosen for examining the pulse.

On the *inner side*, it is in relation with the pronator teres, then with the tendon of the flexor carpi radialis, along which it runs, and which is on a plane anterior to it; so that the contraction of this muscle, by causing its tendon to project, renders the pulsations of the vessel more difficult to be felt.

On the *outer side*, it is in relation with the supinator longus, and in the middle part of its course with the radial nerve (the continuation of the musculo-spiral), which is situated at some distance from it, both above and below, and has a separate fibrous sheath.

Of the *collateral branches* of the radial artery in the *fore-arm*, only three require a special description, viz. the *anterior radial recurrent*, the *anterior carpal branch*, and the *radio-palmar* artery.

The *anterior radial recurrent* artery (*r*, *figs*. 210, 211.) is given off from the back part, and immediately below the origin of the radial. It is very large in some subjects, indeed as large as the radial itself: it descends a little, and then turning upwards, so as to describe a curve with its convexity directed downwards, it ascends between the supinator longus and the brachialis anticus, in order to anastomose with that part of the profunda superior which forms the external collateral branch of the elbow. I have seen this recurrent artery arise from the ulnar.

From the convexity of the arch described by the radial recurrent, a great

number of branches proceed obliquely downwards and outwards, and are distributed to all the muscles on the external aspect of the fore-arm, viz. the long and short supinators, and the two radial extensors. One of these branches passes transversely between the long supinator and the long radial extensor, to anastomose on the outer condyle with the profunda artery; others pass between the radius and the muscles attached to it, ramifying in the extensor muscles of the fore-arm, and anastomose with the posterior interosseous artery derived from the ulnar.

The *anterior carpal branch of the radial artery* is a small branch (*a*, *fig.* 211.) which passes transversely inwards at the lower margin of the pronator quadratus muscle, and anastomoses with a similar branch from the ulnar artery.

The *radio-palmar* or *superficial palmar artery* (*superficialis volæ*, *s*, *fig.* 210.) arises at an acute angle from the inner side of the radial, at the point where that vessel turns outwards to pass over the carpus. Sometimes its origin is situated at the junction of the lower with the two upper thirds of the fore-arm. It varies much in its size and distribution; most commonly it passes vertically downwards, on a level with the anterior ligament of the carpus, perforates the origin of the short abductor of the thumb, and anastomoses with the extremity of the superficial palmar arch (*t*) of the ulnar (*g*). Several branches arise from its convexity, and are distributed to the muscles and integuments of the ball of the thumb. The radio-palmar branch is frequently very small, is entirely lost in those muscles, and does not assist in the formation of the superficial palmar arch. On the contrary, it is often so large, that it may be regarded as formed by the bifurcation of the radial, and then assists as much as the ulnar in forming the superficial palmar arch. In some cases in which the superficial palmar arch did not exist, I have seen the radio-palmar give origin to the internal collateral artery of the thumb, both collateral arteries of the index, and the external collateral of the middle finger, the ulnar artery furnishing the collaterals of the other fingers. In one case a transverse branch, resembling the anterior communicating artery of the brain, formed the anastomosis between the radio-palmar and the ulnar arteries.

The *second* or *carpal* portion of the radial artery extends from the styloid process of the radius to the upper part of the first interosseous space. Closely applied to the ligaments and bones of the carpus, it passes at first obliquely downwards and inwards, and then becomes vertical as it dips into the interosseous space, to pass between the two heads of the first dorsal interosseous muscle. It is well protected on the outer side of the carpus by the projecting tendons of the two extensors and the long abductor of the thumb, all of which cross it obliquely, and separate it from the skin; but between the tendons of the long abductor of the thumb and the long radial extensor it becomes sub-aponeurotic, and therefore very superficial. In this short course it gives off several branches.

The *dorsal carpal branch* of the radial artery, more remarkable for its constancy and the mode of its distribution than for its size, which is inconsiderable, arises opposite the articulation of the two rows of carpal bones, passes transversely inwards, and terminates either by being lost in the adjacent parts, or by anastomosing with the corresponding branch of the ulnar artery. From the arch thus formed proceed certain *ascending branches*, which anastomose with twigs from the anterior interosseous artery, sometimes appearing to form the termination of that vessel, which, as we shall presently describe, becomes posterior at the lower part of the fore-arm; and also some *descending branches*, of very variable size, which having reached the upper part of the third and fourth interosseous spaces in particular, anastomose with the perforating branches of the deep palmar arch, and form one of the origins of the small twigs, which are named the *dorsal interosseous* arteries of those spaces.

The *dorsal interosseous branch for the second space*, known also as the *dorsal metacarpal* branch of the radial artery, is sometimes so large that it seems to

be a continuation of the radial, and at other times very small, and as it were a mere vestige. It often arises by a common trunk with the dorsal carpal branch just described; it runs along the dorsal surface of the second interosseous space, and having reached the lower part of it, gives *superficial dorsal* arteries to the index and middle fingers, and then bends forwards between the heads of the second and third metacarpal bones, to anastomose with that digital branch of the superficial palmar arch which gives off the internal collateral artery of the index, and the external collateral artery of the middle finger.*

The *interosseous artery of the first space* is so large, that it is described as formed by the bifurcation of the radial: it arises from that artery between the first and second metacarpal bones, and sometimes runs along the dorsal aspect of the first interosseous space, and at others between the first dorsal interosseous muscle and the adductor pollicis; in either case, when it reaches the lower part of the space, it divides into two branches, which may arise separately from the carpal portion of the radial artery, as in *fig.* 211., and which constitute the *internal collateral artery of the thumb* and the *external collateral artery of the index finger* (*x*). The *external collateral artery of the thumb*, sometimes derived from the preceding, or even from the extremity of the superficial palmar arch, crosses the muselcs of the ball of the thumb obliquely, to reach the outer side of its metacarpo-phalangal articulation (*v*, *fig.* 210.), and runs along the outer border of the thumb.†

The deep Palmar Arch.

The *third* or *palmar* portion of the radial artery constitutes the *deep palmar arch* (*b*, *fig.* 211.), which is completed by inosculating with a branch of the ulnar, in the same manner as we have seen the superficial palmar arch of the ulnar artery completed by a branch of the radial. This arch is situated deeply across the front of the metacarpal bones, immediately below their upper extremities; it rests immediately upon them and the interosseous muscles, and is therefore subjacent to all the nerves, tendons, and muscles (except the interosseous) in the palm of the hand. The deep palmar arch describes a slight curve, the convexity of which is directed downwards. I have seen the palmar arch formed by the dorsal artery of the second interosseous space, which then dipped between the *upper* ends of the second and third metacarpal bones.

The deep palmar arch gives off very short *superior* or *ascending branches* (*recurrentes*), which are lost in front of the carpus, anastomosing with the anterior carpal branches of the radial and ulnar arteries; also some *descending* or *palmar interosseous arteries* (*d d*; interosseæ volares, *Haller*), three or four in number, which descend vertically along the interosseous spaces, and anastomose with the descending digital branches (cut across in *fig.* 211.) of the superficial palmar arch, either opposite or above their bifurcation into the collateral arteries of the fingers. The size of the palmar interosseous arteries is extremely variable, as well as that of the deep palmar arch itself; it bears an inverse proportion to that of the superficial palmar arch and its branches. The relative size of the different palmar interosseous arteries, also, varies much; most generally the first is the largest, at other times the second, and occasionally the third.

The *deep palmar* arch also gives off the *posterior* or *perforating branches*

* [Three small branches, two of which usually arise by a common trunk, are given off from the radial artery near the *dorsal* aspect of the head of the first metacarpal bone; two of them form the *superficial dorsal arteries* of the two sides of the thumb (*dorsales pollicis*), whilst the other is the *dorsal artery* of the radial side of the *index* finger (*dorsalis indicis*).]

† [The two collateral arteries of the thumb, and the external collateral of the index finger, frequently arise in a different manner from that described above: thus the two arteries for the thumb may take origin from a common trunk, which is then named the *great or principal artery of the thumb* (*magna vel princeps pollicis*); whilst the artery for the index finger arises separately, and is named the *radial collateral artery of the index finger* (*radialis indicis*).]

(*c c*). These are three in number, and form for the second, third, and fourth interosseous spaces what the radial itself is for the first, with this difference, that the radial perforates the first space from behind forwards, whilst these perforating branches traverse the corresponding spaces from before backwards. They arise from behind the deep palmar arch, and immediately perforate the upper part of the interosseous spaces in a straight line, and having reached the dorsal aspect of the hand, generally anastomose with the corresponding dorsal interosseous arteries, which in a great number of cases are formed entirely by these perforating branches. In some subjects, the dorsal interosseous arteries result from the anastomoses of the perforating arteries with the interosseous arteries derived from the dorsal carpal arch formed by the dorsal carpal branches of the radial and ulnar arteries; they pass vertically downwards on the dorsal surface of the interosseous spaces, and having reached their lower parts, anastomose with the descending digital branches of the superficial palmar arch, and thus assist in the formation of the collateral arteries of the fingers.

The Ulnar Artery and its Branches.

The *ulnar artery* (*g*, *figs.* 210, 211.), which is larger than the radial, leaves that vessel at a very acute angle, passes at first downwards, inwards, and backwards, in front of the ulna, describing a slight curve, the convexity of which is directed upwards and inwards, and then descends vertically. Having arrived at the wrist, it is placed on the outer or radial side of the pisiform bone, in front of the annular ligament of the carpus, and then enters the palm of the hand, where it describes beneath the palmar fascia an arch, which has its convexity turned downwards, and is named the *superficial palmar arch* (*t*, *fig.* 210.; removed in *fig.* 211.).

Fig. 211.

The *relations* of the ulnar artery must be separately examined in the fore-arm and in the hand.

In the *fore-arm*, it is at first covered by the thick bundle of muscles which are attached to the inner condyle of the humerus, and also by the median nerve, from which it is separated by that part of the pronator teres which arises from the coronoid process; it is then covered by the flexor sublimis, and finally by the fascia and skin; the tendon of the flexor carpi ulnaris is upon its inner side, and that of the flexor sublimis on its outer: these two tendons by their projection occasion an interval between the artery and the skin. It is in relation behind with the brachialis anticus, the flexor profundus digitorum, and the pronator quadratus. The ulnar nerve is applied to the inner side of the artery at the point where the vessel becomes vertical, and accompanies it as far as the hand. The median nerve is situated on its inner side at the bend of the elbow, but afterwards becomes anterior, and then external to it. In some cases of high division of the humeral artery, the ulnar has been found immediately under the fascia in its whole length.

In the hand, it is at first situated on the outer or radial side of the pisiform bone, and then in front of the hook-like process of the unciform bone; finally, where it forms the superficial palmar arch, it is entirely sub-aponeurotic.

In the fore-arm, the ulnar artery gives off a great number of unnamed collateral branches, which are divided into internal, external, anterior, and posterior, and are distributed to the muscles and integuments. Four branches, however, require special notice, viz. in the fore-arm, the *common trunk of the ulnar recurrents*, the *interosseous* artery, the

the *branch for the median nerve*, and the anterior *artery of the carpus;* in the palm of the hand, the ulnar artery gives off the *collateral arteries of the fingers.*

The *anterior and posterior ulnar recurrent* arteries generally arise by a common trunk, which is given off from the back of the highest portion of the ulnar artery, passes transversely inwards, and divides into two branches — an anterior and a posterior. The former, or *anterior ulnar recurrent* artery (*e, fig.* 211.), passes between the brachialis anticus and pronator teres, gives branches to all the muscles attached to the inner condyle, and anastomoses with the internal collateral branch from the brachial. The other branch, the *posterior ulnar recurrent*, is larger than the anterior, runs behind the muscles arising from the inner condyle, is then situated between that condyle and the olecranon, passes between the two origins of the flexor carpi ulnaris in front of the ulnar nerve, anastomoses freely with the internal collateral branch of the brachial artery and with the interosseous recurrent, and contributes to form an arterial network upon the back of the elbow joint. The branch given off by the posterior ulnar recurrent to the ulnar nerve deserves to be pointed out; it may be traced from below upwards, along that nerve, and anastomoses with the other branches given off to the same nerve from the brachial artery.

The *interosseous artery* is so large that it appears to be the result of a bifurcation of the ulnar, and is described as such by many anatomists; it comes off from the back of the ulnar, immediately below the trunk of the recurrents, on a level with the bicipital tuberosity of the radius; it not unfrequently arises from the radial. Lastly, in several cases of high division, either of the brachial or of the axillary artery, the interosseous has been found to constitute one of the branches of the bifurcation, the other branch being the common trunk of the radial and ulnar arteries.

Immediately after its origin, the interosseous passes directly backwards, and divides into two branches of almost equal size, which are named from their distribution, the *anterior* and *posterior interosseous.*

The *anterior interosseous* (*f, fig.* 211.) descends vertically in front of the interosseous ligament, and is held down to it by a layer of fibrous tissue *: it is placed behind the flexor profundus digitorum and the flexor longus pollicis, in the cellular interval between these muscles. Having reached the upper borders of the pronator quadratus, it passes between that muscle and the interosseous ligament, rests upon the latter, and perforates it towards its lower part: having thus reached the back of the forearm, the anterior interosseous descends upon the dorsal surface of the carpus, and terminates by anastomosing with the dorsal carpal branches of the radial and ulnar. Whilst perforating the interosseous ligament behind the pronator quadratus, the artery almost always gives off a small twig, which descends perpendicularly to join the arch formed by the anterior arteries of the carpus.

In one case where the radial artery was exceedingly small, indeed in a rudimentary state, its place was supplied by the anterior interosseous; which, after having passed behind the pronator quadratus, escaped forwards under the lower border of that muscle, and passed transversely outwards, to anastomose with the rudimentary radial artery, which, thus reinforced, immediately assumed its usual size.

During its course, the interosseous artery only gives off some small branches to the front of the fore-arm, among which the *artery of the median nerve* deserves special notice; but several large branches are detached in succession from its posterior aspect, and immediately perforate the interosseous ligament: they are called the *perforating arteries of the fore-arm*, and are distributed to the deep layer of muscles on the back of the fore-arm. I have seen one of these

* After amputation of the fore-arm, the interosseous artery becomes retracted between this fibrous layer and the interosseous ligament; and it is hence so difficult in some cases to place a ligature upon it, that it has been recommended to divide the interosseous ligament for a short distance.

run along the posterior surface of the interosseous ligament, in the same manner as the anterior interosseous artery.

The *artery of the median nerve* is remarkable for its constancy and its length; it comes off from the front of the anterior interosseous artery, reaches the posterior surface of the median nerve, penetrates it, and then runs downwards along its inner side. I have seen the artery of the median nerve very large, and anastomosing with the superficial palmar arch. It has also been found continuous with the brachial artery, and supplying the place of both the radial and ulnar, which were in a rudimentary state.

The *posterior interosseous* artery is generally smaller than the anterior; it perforates the interosseous ligament opposite the lower border of the supinator brevis, and immediately gives off an ascending branch, the *interosseous recurrent;* it then descends between the deep and superficial layer of muscles on the back of the fore-arm, and divides into a number of branches, which are distributed to those muscles, but especially to the superficial layer.*

The *interosseous recurrent* is a branch of the posterior interosseous, of such size that it may be regarded as resulting from the bifurcation of that artery: it passes vertically upwards, having the anconeus and the extensor carpi ulnaris behind it, and the supinator brevis in front of it; it runs behind the inner condyle, and anastomoses on the outer side of the elbow joint with the cutaneous, muscular, and periosteal divisions of the superior profunda artery, the external collateral branch of the brachial.

The *anterior carpal branch* of the ulnar artery is a small twig, which arises opposite the lower borders of the pronator quadratus, passes between the tendon of the flexor carpi ulnaris and the ulna, and anastomoses with a similar branch from the radial, to form the anterior carpal arch, from which several branches descend to reach the interosseous muscles and those of the ball of the thumb.†

The Superficial Palmar Arch.

Opposite the articulation between the two rows of carpal bones, and before it forms the superficial palmar arch, the ulnar artery gives off a deep branch backwards, called the *radio-cubital*, or communicating artery (*y*, *fig.* 210.); which dips between the short abductor and short flexor of the little finger, then passes outwards between the short flexor and opponens, to anastomose with and complete the deep palmar arch. This artery is sometimes so large that it may be regarded as formed by the bifurcation of the ulnar.

The *superficial palmar arch* (*t*, *fig.* 210.), which constitutes the termination of the ulnar, gives off no important branch from its upper or concave side. Four or five diverging *digital branches* pass from its lower or convex side, and constitute the collateral arteries of the fingers.

The *digital branches* (*u u u*) are distinguished as the first, second, third, and fourth, proceeding from within outwards. The first reaches the inner or ulnar border of the little finger, and constitutes its *internal collateral* artery; the second runs along the fourth interosseous space, and divides into the *external collateral artery of the little finger* and the *internal collateral artery of the ring finger*; the third runs along the third interosseous space, and supplies the *external collateral artery of the ring finger* and the *internal collateral artery of the middle finger*; the fourth runs in the second interosseous space, and gives the *external collateral artery of the middle finger* and the *internal collateral artery of the index finger*. It is very rare to find the external collateral artery of the

* Some branches may be traced as far as the carpus.

† [There are usually two other branches given from the ulnar in the wrist; the first is a *dorsal metacarpal* branch, which arises above the anterior carpal, runs under the tendon of the flexor ulnaris, turns round the ulna to reach the back of the carpus, anastomoses with the dorsal metacarpal branch of the radial, and sends a twig along the fifth metacarpal bone, to form the *superficial dorsal* artery of the little finger. The second branch of the ulnar in this situation may arise with the one just described; it is a *posterior* or *dorsal carpal* branch, which passes backwards, and anastomoses beneath the extensor tendons with the dorsal carpal branch of the radial artery.]

index finger (x) and the internal collateral of the thumb derived from the superficial palmar arch; and still more rare to see the external collateral artery of the thumb (v) given off by that arch.

Whatever varieties there may be in the arteries of the palm of the hand, in reference to the share which the radial and ulnar respectively take in the formation of the collateral arteries of the fingers, the following general facts are apparent in their distribution:—The size of the superficial and deep palmar arches respectively are always inversely proportioned to each other; the communication between the two arches takes place not only directly between the arches themselves, but also indirectly in a great number of points by their branches; all the descending branches of the deep palmar arch anastomose with the angle of bifurcation of the descending branches of the superficial palmar arch; those from the deep arch are sometimes smaller, sometimes larger, than those from the superficial arch; they are rarely of the same size, but always bear an inverse ratio to them; the bifurcation of each digital branch of the superficial palmar arch takes place two or three lines below the metacarpo-phalangal articulation, opposite the junction of the body with the upper end of the first phalanx; the collateral arteries of the fingers are situated upon the anterior aspect of the phalanges, on each side of the sheath of the flexor tendons; they give off dorsal and palmar branches, and anastomose with each other in front of the body of the phalanges by small transverse branches; having reached the middle of the last phalanx, they anastomose in an arch, from the convexity of which a great number of anterior branches pass to the skin, over the last phalanx, and some dorsal branches to the matrix of the nail; one of these branches runs along the curved adherent border of the nail.

The *termination of the superficial palmar arch* is subject to variety: thus, it terminates either by anastomosing with the radio-palmar or superficialis volæ, of the same size as itself, or by receiving a very small radio-palmar branch, and being prolonged so as to constitute the common trunk of the internal collateral artery of the thumb and the external collateral artery of the index finger; or else it terminates in the external collateral of that finger; or, lastly, after having given off the internal collateral of the thumb and the external collateral of the fore-finger, it ends in the external collateral of the thumb. At other times, again, there is no superficial palmar arch properly so called, and the ulnar artery terminates by furnishing the collaterals of the little and ring fingers and the internal collateral of the middle finger, the other collaterals being derived from the radio-palmar, which is then very large. In certain cases, a very small transverse branch forms the communication between the radial and the ulnar arteries.

General Remarks on the Arteries of the Upper Extremity.

A single trunk, which may be called the brachial trunk, supplies the whole of the upper extremity; it forms, in succession, the subclavian, the axillary, and the brachial artery, which latter bifurcates near the bend of the elbow into the radial and ulnar arteries: these form the palmar arches, from which the arteries of the fingers take their origin.

The difference in the origin of the right and left brachial trunks has been considered to account for the difference in strength between the two arms; and the different size of the two vessels has also been supposed to be connected with the same fact, which however, in reality, depends upon the more frequent exercise of the right than of the left arm.

The brachial trunk is not exclusively distributed to the upper extremity, but supplies the most dissimilar parts; a fact which shows that the conditions of origin, which have so great an influence in regard to nerves, are altogether without importance in reference to the arteries. Thus, the brachial trunk sends branches to the following parts:—the vertebral artery to the brain, the cerebellum, the pons varolii, the medulla oblongata, and the spinal cord; the in-

ferior thyroid artery, to the thyroid gland, the larynx, the trachea, the œsophagus, and sometimes the bronchi; the internal mammary and thoracic arteries to the corresponding mamma; and the same arteries, together with the superior intercostal, to the parietes of the thorax and abdomen; the ascending cervical to the prævertebral muscles and the spine; and, lastly, the deep cervical, sub-scapular, and posterior scapular arteries to the superficial and deep muscles of the back of the neck.

Setting aside those branches which do not belong to the upper extremity properly so called, we find that, during its course along the limb, the artery always occupies the aspect of flexion, which is at the same time the position where it can be best protected; and that, for this purpose, it is directed from the axilla to the bend of the elbow: we find, also, that it gives off a great number of anastomotic branches around the articulations, and thus establishes a collateral circulation, through which the blood can pass when the principal artery is obliterated. This anastomosis, and consequently the collateral circulation is effected by the cutaneous, muscular, and periosteal branches, and even by those distributed to the nerves. Thus, along the clavicle, we find the acromio-thoracic in front, and the supra-scapular or transversus humeri behind; around the scapula there are the supra-scapular on the upper border, the posterior scapular on the vertebral border, and the subscapular on the axillary border; so that that bone is completely surrounded by an anastomotic triangle.

Around the elbow joint are the external and internal collateral branches of the brachial artery, and the radial, ulnar, and interosseous recurrents.

Around the wrist we find the anterior and posterior carpal arteries, and also anastomotic arches around the metacarpo-phalangal and phalangal articulations.

On comparing the size and number of the arteries of the arm and fore-arm with the size and number of the arteries of the hand, it will be seen that the latter has greatly the advantage: indeed, in this part of the body, there is an unusual distribution of the arterial system into a deep and a superficial set of vessels, precisely as is the case with the veins. Why is this? Is it not extremely probable, that, as the deep veins are intended to supply the place of the superficial, when the circulation in the latter is for a time impeded, so in the hand the arteries are arranged in a similar manner, because the superficial circulation is liable to be interrupted by pressure from grasping hard bodies firmly in the hand for a longer or shorter period? and is it not for the same reason, that the superficial system derived from the ulnar artery has so many communications with the deep system given off from the radial?

It is worthy of remark that the radial, which is the superficial artery of the fore-arm, becomes deep-seated in the hand; and that the ulnar, which is deep-seated in the fore-arm, becomes superficial in the hand.

The great quantity of blood circulated through the hand is connected with the active use of that part, in the almost constant exercise of the sense of touch, and in prehension.

ARTERIES ARISING FROM THE TERMINATION OF THE AORTA.

Enumeration. — *The middle sacral.* — *The common iliacs.* — *The internal iliac, or hypogastric — the umbilical — the vesical— the middle hæmorrhoidal — the uterine — the vaginal — the obturator — the ilio-lumbar — the lateral sacral — the glutæal — the sciatic — the internal pudic.* —*Summary of the distribution of the internal iliac.* — *Artery of the lower extremity.* — *The external iliac — the epigastric — the circumflex iliac.* —*The femoral — the superficial epigastric — the external pudic — the muscular — the deep femoral, its circumflex and perforating branches.* — *The popliteal and its collateral branches.* — *The anterior tibial and the dorsal artery of the foot.* — *The tibio-peroneal — peroneal — posterior tibial, and the internal and external plantar.* —*Comparison between the arteries of the upper and lower extremities.*

The arteries arising from the termination of the aorta are the middle sacral and the two common iliac arteries.

The Middle Sacral Artery.

The *middle* or *anterior sacral artery* (*n*, *fig.* 199.), the small median artery of the sacrum, arises from the lower and back part of the aorta, a little above its termination. Like the aorta, it is a single vessel, and seems to be the continuation of it, as far as direction is concerned; which, indeed, is really the case in such animals as are provided with a tail. Sometimes, but rarely, it arises from the left common iliac, or the last lumbar artery. I have seen it arise by a common trunk with the two lower lumbar arteries. It passes vertically downwards in front of the fifth lumbar vertebra, the sacrum and the coccyx being closely applied to them all. It is situated in the median line at its origin, but sometimes deviates to one side or the other. In size it is scarcely equal to one of the lumbar arteries, and it gradually diminishes from its origin to the first bone of the coccyx, towards the apex of which it terminates in a very variable manner.

The size of the middle sacral is generally inversely proportioned to that of the lowest lumbar arteries. When the aorta divides higher than ordinarily, and the last lumbar is given off from the middle sacral, the last named artery is of course unusually large.

During its course, the middle sacral gives off, opposite the fifth lumbar and each of the sacral vertebræ, a right and left lateral branch, which correspond with the series of intercostal and lumbar arteries. The two *lumbar branches* are generally small, but are very large when the fifth lumbar arteries are neither furnished by the aorta, nor by the fourth lumbar, nor by the ilio-lumbar. The lateral branches given off upon the sacrum pass transversely outwards, supply twigs to the periosteum and bone, and anastomose with the lateral sacral, the place of which they sometimes supply within the interior of the sacral canal.

The middle sacral having become very slender near the base of the coccyx, bifurcates in order to form an anastomotic arch with the right and left lateral sacral arteries. I have seen its lower end divided into three branches, of which the median was prolonged as far as the tip of the coccyx, whilst the lateral branches anastomosed with the lateral sacral arteries.

The Common Iliac Arteries.

The *primitive* or *common iliac arteries* (*i i*, *figs* 199. 212.), the two branches into which the aorta subdivides, commence opposite the lower margin of the fourth lumbar vertebra, and terminate by bifurcating opposite the base of the

sacrum; they separate from each other at an acute angle, pass obliquely downwards and outwards, and form the two sides of an isosceles triangle, the base of which corresponds with the transverse diameter of the fifth lumbar vertebra. These arteries are generally straight, but not unfrequently they are tortuous in aged persons. In the adult they are about two inches long, the right being rather longer than the left, from the position of the aorta; but they are often much shorter, on account of their bifurcating higher than usual. Meckel has remarked that this premature bifurcation is more common on the left than on the right side. In a specimen deposited in the museum of the Ecole de Médécine, the right common iliac is entirely wanting; the aorta dividing into three branches, two on the right, viz. the internal and external iliacs, and one on the left, viz. the common iliac, which is distributed in the usual manner.

Relations. They are covered by, and are loosely connected with, the peritoneum; they are crossed by the ureters and the spermatic vessels, besides which the left common iliac is crossed by the inferior mesenteric artery; they are surrounded by a great number of lymphatic glands, and rest above upon the vertebral column, and on the outside and below upon the inner side of the psoas muscle.

It is of great importance to comprehend their relations with the common iliac veins. The veins are situated behind the arteries; but as the right and left vein unite on the right side of the vertebral column, the left common iliac vein comes into relation with both common iliac arteries.

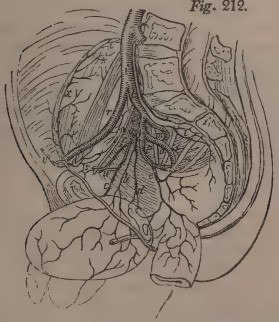
The *common iliac artery* gives off no collateral branch; it merely supplies some twigs to the cellular tissue, the lymphatic glands, and the coats of the common iliac veins. It occasionally gives off one of the renal arteries; and it has been seen to supply the spermatic and the ilio-lumbar arteries.

Terminal branches. The common iliac artery terminates by dividing into two branches, which remain in contact with each other for a short distance: the internal branch dips into the pelvis, and is called the *internal iliac* or *hypogastric* artery; the external branch continues in the original course of the common iliac, and is termed the *external iliac* artery.

The Internal Iliac or Hypogastric Artery.

The *internal iliac* or *hypogastric* artery (*t, figs.* 199. 212.) is distributed to all the organs contained in the cavity of the pelvis; to the muscles which line it within and cover it without; to the external and internal organs of generation, and to the integuments.

Fig. 212.



It passes at first obliquely downwards and forwards, and, as it were, in contact with the external iliac; it then dips vertically into the pelvis in front of the sacro-iliac synchondrosis, describing a short curve; and after a course of about one inch or one inch and a half in length, divides opposite the upper part of the sacro-sciatic notch into a greater or less number of branches, which do not always arise in the same way from the principal trunk, but whose ultimate distribution is constant. It is covered by peritoneum, and is crossed by the ureter; it rests behind on the lumbo-sacral nerve and pyriformis muscle; and the internal iliac vein is behind and to its outer side.

Its branches, all of which sometimes arise from two principal trunks, one anterior and the other posterior, may be divided into an *anterior* set, consisting of the *umbilical, vesical, obturator, middle hæmorrhoidal, uterine, vaginal, sciatic,*

and *internal pudic* arteries; and a *posterior* set, including the *ilio-lumbar*, *lateral sacral*, and *gluteal* arteries. Altogether there are nine in the male and eleven in the female.

The Umbilical Artery.

The *umbilical artery*, which is so large in the fœtus, is converted into an impermeable cord (*u*, *fig.* 212.) in the adult, excepting near its origin (*a*), where it gives off some vesical branches: the examination of the umbilical arteries belongs therefore, more especially, to the anatomy of the fœtus. They are intended to convey the blood of the fœtus to the placenta, and are then the continuations of the common iliac arteries. The external and internal iliacs being very small at that period, in correspondence with the small size of the abdominal extremities, appear to be nothing more than divisions of the umbilical.

The umbilical arteries pass downwards, forwards, and outwards, and having arrived at the sides of the bladder, run along them, in order to reach the umbilical ring, through which they emerge from the abdomen, and having traversed the whole length of the umbilical cord in a spiral and tortuous manner, are at length distributed to the placenta.

The vesical, middle hæmorrhoidal, uterine, vaginal, and obturator arteries are given off in succession from the apparently ligamentous cord formed by the umbilical artery near its origin.

The Vesical Arteries.

These are variable in number: the principal of them on each side are given off from the umbilical artery (*a*), which seems to be converted into a ligamentous cord (*u*) at the place where the vesical arteries arise, but which is in reality pervious. This ligamentous appearance of the umbilical arteries depends upon the narrowness of their canal, as compared with the thickness of their coats. Other vesical branches arise from the middle hæmorrhoidal and obturator arteries and in the female from the uterine and vaginal. We shall divide the vesical arteries into the *posterior*, the *anterior*, and the *inferior*.

The *posterior vesical artery* (*b*, *fig.* 212.) frequently arises, in the female, by a common trunk with the uterine. It reaches the base of the bladder, on the outer side of the ureter, passes inwards and upwards upon the posterior surface, as far even as the summit of that viscus. I have seen the right posterior vesical artery, of large size, running along the posterior surface of the bladder in the median line, and prolonged upon the urachus; the left posterior vesical was very small, and, in fact, rudimentary.

The *anterior vesical* (*c*) arises from the umbilical, from the obturator, and sometimes from the internal pudic artery. When it arises from the umbilical, it is given off from that artery opposite the sides of the bladder, and passes downwards and inwards along its anterior surface. I have seen it given off near the summit of that organ. When it arises from the obturator or the internal pudic, it traverses the anterior ligament of the bladder, and passes upwards upon the front of that organ.

I have seen a very large vesical artery given off from the obturator, which in that case arose from the epigastric, and further the vesical artery arose by a common trunk with the artery of the corpus cavernosum.

The *inferior vesical* (*d*), which often arises direct from the internal iliac, reaches the inferior fundus of the bladder, and ramifies abundantly upon it and the commencement of the urethra: in the male it also supplies the corresponding vesicula seminalis and vas deferens, the branch to which is called the deferential artery, and the prostatic portion of the urethra. I have seen the dorsal artery of the penis arise from the inferior vesical.

The Middle Hæmorrhoidal Artery.

This is a small artery (*e*), which is sometimes wanting, its place being then supplied by branches from different sources, but especially from the sciatic or the internal pudic; it passes upon the sides of the anterior surface of the rectum, where it terminates by anastomosing with the superior and inferior hæmorrhoidal arteries.

The Uterine Artery.

The *uterine artery* (*n n*, *fig.* 198.) arises from the umbilical, near the posterior vesical, and frequently by a common trunk with it; passes transversely inwards to the corresponding lateral border of the uterus, a little above the os tincæ; is reflected upwards along the uterus, and terminates by expanding into several ascending branches, of which the anterior reach the front, the posterior the back, and the middle the upper border of the viscus, and inosculate either with their fellows of the opposite side, or with the uterine branches of the ovarian artery. The uterine arteries are remarkable for the great size which they acquire during pregnancy, and also for their tortuous and spiral course, even to their smallest branches — a disposition which no other artery presents in the same degree. These tortuosities, instead of diminishing, appear to increase during pregnancy — a fact which seems opposed to the view generally adopted regarding the use of arterial flexuosities in organs liable to variations in their size.

Collateral branches. At the point of its reflection, each uterine artery gives off one or more descending branches between the vagina and the bladder to supply both parts; in their course along the borders of the uterus, they furnish a series of anterior and posterior ascending branches, which are distributed in the same way as the terminal ascending branches; they all anastomose in the median line with their fellows of the opposite side.

Relations. The trunks of the uterine arteries are beneath the peritoneum; the principal branches are situated under a thin layer of the substance of the uterus, and the ultimate divisions and subdivisions enter its tissue.

The Vaginal Artery.

The *vaginal artery* arises from the umbilical, sometimes before, sometimes after the origin of the uterine, which is sometimes given off from a common trunk with it. It is as large as the uterine in young subjects, but is smaller than it after puberty. It descends directly upon the sides of the vagina, to which it gives off a numerous series of branches, supplies a considerable branch to the neck of the bladder and the urethra, gives an equally large one to the bulb of the vagina, and then passes backwards between the orifice of the vagina and the rectum, and anastomoses with its fellow of the opposite side.

The Obturator Artery.

The *obturator artery* (*f*, *fig.* 212.) is remarkable for the varieties of its origin, and for the important consequences which result from those varieties, in reference to the operation for femoral hernia.

It generally arises from the internal iliac by the side of the umbilical, but sometimes above the gluteal; it is almost as frequently given off from the external iliac, either directly, which is rare, or by a common trunk with the epigastric. Lastly, and much more rarely, it arises from the femoral artery.

The course of the obturator artery is modified by these differences of origin, which, notwithstanding the assertion of some anatomists, are as common in the male as the female, and which may occur on one side only, or on both

sides of the same subject. Thus, when the obturator comes from the femoral, it passes upwards on the inner side of the femoral vein, enters the pelvis through the crural ring, is reflected upon the upper surface of the body of the os pubis, then passes behind it and gains the internal opening of the subpubic canal. When it arises by a common trunk with the epigastric, it dips vertically behind the os pubis to the same opening. In its ordinary mode of origin, it passes horizontally forwards upon the sides of the brim of the pelvis, being bound down by the peritoneum, runs parallel with the obturator nerve (*n*), which is placed above it, gains with it the internal orifice of the subpubic canal, and having traversed this passage, divides into an *internal* and an *external* terminal branch.

Collateral branches. Near its origin, the obturator artery gives off a tolerably large branch, the *iliac*, which perforates the iliac fascia, dips between the iliacus muscle and the iliac fossa, and anastomoses with a branch of the circumflex iliac artery.

As it enters the subpubic canal, it gives off a small branch, which passes transversely behind the body of the pubis, and ramifies upon the side of the symphysis, anastomosing with its fellow of the opposite side; also a small ascending branch (*s*), which anastomoses with the epigastric artery, and which may be regarded, according to Meckel, as one of the origins of the obturator, so that the variety in which the obturator arises from the epigastric is often nothing more than an unusual developement of this communicating branch. In support of this view, we may quote the very rare case, in which the obturator arises by two roots of almost equal size, one coming from the epigastric, and the other from the internal iliac.

Terminal branches. The *internal branch* passes between the obturator externus muscle and the conjoined rami of the pubes and ischium, so as to describe a semicircle around the inner half of the obturator foramen, gives branches to the periosteum of the os pubis, muscular branches to the two obturator and to the adductor muscles, some genital branches to the coverings of the testis in the male and to the labia majora in the female, and lastly, some very important anastomotic branches, which join those of the internal circumflex.

The *external branch* runs along the outer half of the obturator foramen; it is placed, like the preceding, between the two obturator muscles, and terminates between the neck of the femur and the quadratus femoris muscle by anastomosing with the sciatic artery. This anastomosis is very remarkable. During its course, the external branch supplies the obturator muscles and the hip-joint; the articular branch enters by the notch of the cotyloid cavity, and is lost in the reddish fatty tissue, situated at the bottom of it. The distribution of the obturator artery is much more limited than that of the obturator nerve.

The Ilio-lumbar Artery.

The *ilio-lumbar* artery (*h*) arises from the back of the internal iliac, and tolerably frequently from the gluteal. There are often two ilio-lumbar arteries. This vessel bears the same relation to the lumbar arteries, that the superior intercostal does to the aortic intercostals; its size and distribution vary according to the presence or absence of the fifth lumbar artery.

It has a retrograde course, running upwards and backwards in front of the lumbo-sacral nerve, and behind the psoas muscle, and soon divides into two branches—an *ascending* or *lumbar*, and a *transverse* or *iliac*. The *ascending* or *lumbar branch* passes vertically upwards along the bodies of the lumbar vertebræ, hidden by the psoas, and subdivides into a *muscular* branch, which corresponds to the abdominal branches of the lumbar arteries, and is distributed to the psoas and to the quadratus lumborum; and a *spinal* branch, which enters the vertebral canal by the foramen between the fifth lumbar vertebra and the sacrum, and is distributed in the same manner as the other spinal arteries.

The *transverse* or *iliac branch* passes horizontally outwards, opposite the

brim of the pelvis, and divides into a superficial branch, which passes under the iliac fascia, ramifies upon the iliacus muscle, and anastomoses with the circumflex iliac artery; and into a deep and much larger branch, which passes between the iliacus muscle and the iliac fossa, and divides into muscular and periosteal twigs. The principal nutritious artery of the ilium is derived from this branch.

When there are two ilio-lumbar arteries, the superior represents the lumbar branch, and the inferior the iliac branch: in such a case the latter branch always arises from the gluteal artery.

The Lateral Sacral Arteries.

Most commonly there are two lateral sacral arteries on each side; they belong rather to the interior of the sacral canal than to the cavity of the pelvis, and form a continuation of the spinal branches of the lumbar arteries; they almost as frequently arise from the gluteal as from the internal iliac; sometimes they are derived from the sciatic or the ilio-lumbar arteries.

The *superior lateral sacral* is generally of considerable size. It passes almost horizontally inwards, and after having given off some small transverse branches, which anastomose with the middle sacral, enters the first anterior sacral foramen, and divides into two branches — one intended for the nerves and their coverings, and another which emerges from the sacral canal by the corresponding posterior sacral foramen, and is distributed to the spinal muscles and to the skin.

The *inferior lateral sacral* (*l*, *fig.* 212.) is situated at first under the digitations of the pyriformis muscle, afterwards passes in front of that muscle, and is directed inwards and downwards on the inner side of the sacral foramina, and along the borders of the coccyx, where it anastomoses with the middle sacral. In this course it gives off a series of very small internal branches, which correspond to the several sacral vertebræ, and anastomose with the middle sacral; also some posterior or spinal branches, each of which enters the sacral canal through the corresponding sacral foramen, and subdivides into two small branches — one intended for the nerves and their coverings, whilst the other emerges from the sacral canal by the corresponding posterior sacral foramen, and is distributed to the muscles and the skin. When the superior lateral sacral is small, the posterior or spinal branch of the inferior lateral sacral is very large. The inferior lateral sacral artery often terminates by a spinal branch, which enters at the lowest anterior sacral foramen.

The Gluteal Artery.

The *gluteal artery* (*m*, *fig.* 212.), called also the posterior iliac, is the largest branch of the internal iliac, of which it might be considered the continuation. It might be called *superior gluteal*, in contra-distinction to the sciatic, which is in reality an inferior gluteal. It passes downwards and backwards between the *lumbo-sacral nerve* and the first sacral nerve, escapes from the pelvis at the upper part of the great sacro-sciatic notch, above the pyriformis muscle (*m*, *fig.* 45.), is reflected upon the border of that notch and divides into a *superficial* and a *deep* branch. The *superficial branch* (*a*) passes horizontally forwards, between the glutæus maximus and medius, and is almost entirely distributed to the upper part of the first-named muscle and to the adjacent part of the skin; the *deep branch* (*b*) passes between the glutæus medius and minimus, and subdivides into two branches; the lower of these runs horizontally, and may be traced as far as the anterior border of the glutæus medius, whilst the other very nearly follows the curve described by the origin of the glutæus minimus. This branch gives off some muscular arteries, several nutritious arteries to the bone, and several articular branches.

One circumstance regarding the gluteal artery worthy of remark is the fact, that, in common with all arteries of a certain size, it is liable to aneurism,

and that for the cure of this aneurism (which has always been the result of external violence), the common iliac artery has in two cases been tied in America, and the gluteal artery itself recently by an English surgeon.

The Sciatic Artery.

The *sciatic artery* (*o*, *fig*. 212.), from its distribution, might be called the *inferior gluteal.* It often arises by a common trunk, either with the gluteal or with the internal pudic, behind and internal to which it is situated; it descends in front of the sacral plexus and the pyriformis muscle, traverses the sacral plexus, emerges from the pelvis (*o*, *fig*. 215.) between the pyriformis and the lesser sacro-sciatic ligament, accompanied on its inner side by the great sciatic nerve, and behind by the internal pudic artery (*p*). Outside the pelvis, the sciatic artery gives off *internal* or *transverse* branches, some of which pass transversely inwards between the glutæus maximus and the great sacro-sciatic ligament, whilst others (*c*) perforate that ligament, and ramify in the internal attachments of the glutæus maximus. Several of these branches ramify upon the skin of the coccygeal region; its other branches are *descending*, the largest of which (*d*) gains the deep surface of the glutæus maximus, and enters that muscle by numerous branches, which become cutaneous at their termination; one and often two or three branches (*e*) of the sciatic artery attach themselves to the deep surface of the great sciatic nerve, and accompany it to the lower part of the thigh. A great number of twigs are given off from the several branches of the sciatic artery, which are distributed to the small rotator muscles, or to the origins of the muscles attached to the tuberosity of the ischium, whilst others anastomose with the circumflex (*f*) and perforating arteries (*s*) derived from the femoral. Among these anastomoses, I would point out one very considerable anastomotic loop formed behind the neck of the femur by the sciatic and internal circumflex arteries, and constituting one of the principal communications between the internal iliac and femoral arteries.

The Internal Pudic Artery.

The *internal pudic* (*p*, *fig*. 212.), the terminal branch of the internal iliac, is, practically speaking, the most important of all the pelvic arteries. It is smaller than the sciatic, from which it is sometimes given off, either shortly after the origin of that vessel, or as it is passing out from the pelvis. The internal pudic runs in a tortuous manner downwards, in front of the sacral plexus and the pyriformis muscle, parallel to the sciatic artery (*o*), which is behind it; escapes from the pelvis, together with that vessel (*p o*, *fig*. 215.), between the pyriformis muscle and the spine of the ischium; is reflected upon that process turning round it from behind forwards, so as to embrace in succession its posterior, its external, and its anterior surfaces, and then enters the pelvis again between the two sacro-sciatic ligaments. The artery, after descending a short distance, then becomes ascending, and is situated in the ischio-rectal fossa (*a*, *fig*, 213.), and is applied to the internal surface of the tuberosity of the ischium, or rather of the obturator internus muscle, with which it is kept in contact by a layer of fascia; it is separated from the levator ani by a considerable quantity of fat, and having reached the posterior border of the transversus perinei muscle, it divides into an *inferior*, *superficial*, or *perineal* branch (*c*), and a *superior* or *deep* branch (*e*), which is distributed to the *penis* in the male and to the

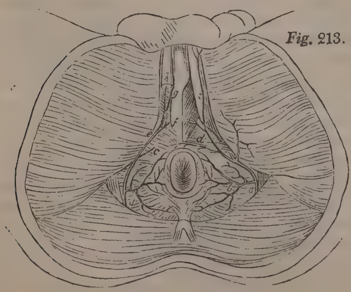


Fig. 213.

clitoris in the female. An important variety in the course of this artery has been pointed out by Burns, who, in a male subject, saw the trunk of the internal pudic instead of passing out of the pelvis run upon the sides of the inferior fundus of the bladder, perforate the upper part of the prostate, and then terminate in the usual manner.

Collateral branches. During its course within the pelvis, the internal pudic supplies branches to the bladder, rectum, vesiculæ seminales, and prostate in the male, and to the vagina in the female; it also rather frequently gives off the middle hæmorrhoidal. As it turns round the spine of the ischium, it gives some branches to the rotator muscles of the thigh. Opposite the internal surface of the tuberosity of the ischium, it gives origin to one or more branches, named the *external* or *inferior hæmorrhoidal* (*b*, *fig.* 213.), which run inwards to be distributed to the lower end of the rectum, to the sphincter, the levator ani, and the skin; also some branches, which proceed outwards, some to supply the periosteum of the tuberosity, whilst others ramify in the muscles attached to that process; lastly, a very important communicating branch passes between the tuberosity of the ischium and the great trochanter, and anastomoses with the sciatic and internal circumflex arteries.

Terminal branches. These differ in the two sexes. We shall first describe them in the male:—

The *inferior branch*, the *superficial artery of the perineum*, or the *perineal artery* (*c*), is smaller than the superior branch; it passes forwards and inwards, in the cellular interval between the ischio-cavernosus and the bulbo-cavernosus; above, *i. e.* deeper than the superficial fascia of the perineum, which separates it from the skin; and below, *i. e.* superficial to the transversus perinei muscle, it thus reaches the dartos at the side of the median line, where it is named the *artery of the septum*, and is distributed to the scrotum and the skin of the penis.

During its course the superficial perineal artery gives internal and external branches. Some of the internal branches run along the posterior border of the transversus perinei muscle, and are sometimes so large as to bleed very profusely when they are divided in the operation of lithotomy; from its situation one of them is named the transverse artery of the perineum (*d*).

The *deep superior* or *deep branch* (*e*), or the *artery of the penis* (in the male), is the continuation of the trunk of the internal pudic, both in regard to size and direction; it runs along the ascending ramus of the ischium, between the layers of the triangular ligament; above, *i. e.* deeper than the transverse muscle, which it sometimes perforates, also above the ischio-cavernosus and the corresponding crus of the corpus cavernosum; and opposite the point at which the two crura unite, it subdivides into two branches, viz. the *dorsal artery of the penis* (*g*), and the *artery of the corpus cavernosum* (*h*).

During its course the artery of the penis gives off a very important collateral branch, named *the artery of the bulb* (*f*), which is as large as the superficial perineal artery, is sometimes double, and generally arises near the bulb, passes transversely inwards, above the middle perineal fascia or triangular ligament, or rather in the substance of that ligament, and is distributed to the bulb of the urethra.

The *dorsal artery of the penis* (*g*) is sometimes the only terminal branch of the internal pudic, and then a very delicate twig supplies the place of the artery of the corpus cavernosum, which, in this case, is supplied from another source. This artery reaches the dorsal surface of the penis by passing between the symphysis pubis and the crura of the corpus cavernosum, and perforating the suspensory ligament of the penis, and then runs in a very tortuous manner along beneath the skin upon the dorsal aspect of that organ, on one side of the median line, being retained in its position by a layer of fibrous membrane; it terminates by ramifying in the prepuce and in the glans, around the base of which it forms a *corona*. I have seen the dorsal artery of the penis given off by one of the external pudic arteries, from which it arose immediately above

the entrance of the saphenous vein into the femoral; it then formed a curve in the groin, with its concavity directed downwards, and passed upon the sides of the dorsal surface of the penis; in another instance, the dorsal artery of the penis was derived from the obturator, or, rather, it had two roots—a very small one, which had the usual origin, and a large one, which arose from the obturator and passed under the symphysis. The right and left dorsal arteries of the penis sometimes anastomose by a transverse branch, like the anterior cerebral arteries.

The *artery of the corpus cavernosum* (*h*) is also sometimes the only terminal branch of the internal pudic artery, the dorsal artery of the penis in such cases being derived from some other source. I have seen the cavernous artery arise from the obturator. In all cases it enters the corpus cavernosum by the corresponding crus, runs along its median septum, and ramifies in its areolar structure.

In the female the terminal branches of the internal pudic are arranged as follows:—the *inferior* or *superficial perineal branch* is larger than the superior, and might be named the *artery of the labia majora*, to which it is distributed; the *superior* or *deep branch*, or the *artery of the clitoris*, runs along in contact with the tuberosity of the ischium, and then with its ascending ramus, and having given off a branch, which runs inwards to the bulb of the vagina, terminates in the *dorsal artery* and *cavernous artery of the clitoris*, these vessels being very small in consequence of the diminutive size of that organ.

Summary of the Distribution of the Internal Iliac Artery.

The internal iliac artery, which is so deeply situated as to be inaccessible to the surgeon, sends branches to all the organs contained in the cavity of the pelvis; to the bony parietes of the pelvis, and the sacral canal; to the muscles which line the pelvis within and cover it without; and to the skin and the external genital organs.

Its several branches may be divided into *parietal* and *visceral*. The *visceral branches* are the vesical, middle hæmorrhoidal, vaginal, and uterine arteries, and the deep branch of the internal pudic. The sympathy existing between all the organs to which the above-named vessels are distributed, depends less upon those vessels having a common source than upon the community of origin of the several nerves which those vessels serve to support.

The *parietal branches* are the ilio-lumbar and lateral sacral arteries, which, with the middle sacral, continue the series of intercostal and lumbar arteries into the sacral region, and supply the sacrum, the spinal nerves and their coverings, and also the muscles of the vertebral grooves and the skin of the sacral region; the glutæal and the sciatic arteries intended for the muscles of the gluteal region; the superficial branch of the internal pudic artery, which supplies the perineum; and, lastly, the obturator artery, which forms an arterial circle around the obturator foramen, and supplies the obturator muscles.

Several branches of the internal iliac artery establish anastomoses between that vessel and the femoral artery; these are more especially the sciatic, the internal pudic, the gluteal and the obturator arteries.

Artery of the Lower Extremity, or Crural Trunk.

The arterial trunk of the lower extremity, or the *crural* trunk (*Chaussier*), corresponds with the brachial trunk of the upper extremity. This vessel, which is the direct continuation of the common iliac artery, passes downwards and outwards, emerges from the pelvis beneath the crural arch, and thus reaches the anterior region of the thigh. Opposite the junction of the two upper thirds with the lower third of the femur, it traverses the fibrous canal formed for it by the tendon of the great adductor muscle, and thus gains the popliteal space, at the lower part of which it terminates by dividing into two branches.

The numerous and important relations of this vessel, and the great number of branches arising from it, have led to its division by anatomists into three portions, which are named the *external iliac artery*, the *femoral* or *crural artery*, and the *popliteal artery*. The two terminal branches are the *anterior tibial*, which, in the foot, is termed the dorsal artery of the foot, and the *tibio-peroneal trunk*, which divides into the *peroneal* and *posterior tibial* arteries, the latter of which terminates in the sole of the foot by subdividing into the *internal* and *external plantar arteries*.

The External Iliac Artery.

The *external iliac artery* (*r*, *figs.* 199. 212.), the outer of the two branches into which the common iliac divides, is analogous to the subclavian artery in the upper extremity. It extends from the highest part of the sacro-iliac symphysis to the lower border of the femoral arch or Poupart's ligament, below which it takes the name of *femoral artery*. It is directed obliquely downwards and outwards, in a line extending from the sacro-iliac symphysis to the crural ring, and is almost always straight, but sometimes tortuous. It has the following relations: *in front* and *on the inner side* it is covered by the peritoneum, which is very loosely attached to it—an important fact, which enables the surgeon to separate that membrane from it in applying a ligature to the vessel; *on the outer side*, it rests against the psoas muscle, from which it is separated by the iliac fascia; *behind*, the artery of the right side is in relation with the corresponding external iliac vein, which is placed to its inner side below; on the left side the vein is below, and on the inner side of the artery; lastly the genito-crural nerve, just as it is about to enter the inguinal canal, crosses in front of this artery, and so also do the spermatic vessels; the circumflex iliac vein crosses it at right angles behind the femoral arch, in order to terminate in the external iliac vein; besides this, it is covered immediately behind the arch by several lymphatic glands; higher up, the ureter crosses obliquely in front of it, and the artery of the right side is covered by the termination of the ileum, and that of the left side by the sigmoid flexure of the colon.

Collateral branches. The external iliac artery furnishes no branches, excepting at its lower part, near the femoral arch, where it gives off the *epigastric* and *circumflex iliac* arteries.

The Epigastric Artery.

The *epigastric artery* is, practically speaking, one of the most important to be well understood, on account of its relations with the crural ring and inguinal canal, that is to say, with the parts through which the viscera generally descend in herniæ.

This artery (*v*, *figs.* 199. 212.) arises from the inner side of the external iliac, two or three lines above the femoral arch. Its origin, however, is subject to some varieties: sometimes it takes place half an inch, one or even two inches, above the crural arch; an important fact in reference to the application of a ligature to the external iliac. Hesselbach and several others, state that they have seen the epigastric arise from the obturator artery; but their descriptions appear to me to prove nothing more than that the epigastric and obturator arteries may arise by a common trunk. It is worthy of remark, that the obturator is often observed to arise from the epigastric, whilst there is, perhaps, no example of the epigastric being derived from the obturator. The obturator so frequently arises by a common trunk with the epigastric *, that many anatomists have thought that the obturator is derived from the epigastric more

* It would be very difficult to explain why the epigastric and the obturator arteries are so intimately connected at their origins.

frequently than from the internal iliac artery. In 250 subjects examined for this purpose by M. Jules Cloquet, the obturator arose 150 times from the epigastric on both sides, 28 times on one side only, and 6 times from the femoral artery.

The epigastric artery, whether it gives off the obturator or not, passes transversely or obliquely inwards, and having arrived below the spermatic cord in the male, and the round ligament in the female, is reflected upwards, so as to describe a curve having its concavity directed upwards, and corresponding to the loop formed by the spermatic cord or round ligament, the concavity of which is directed downwards. When the obturator arises by a common trunk with the epigastric, it is given off at the point where the latter is reflected upwards, and from the convexity of the curve. After being reflected, the epigastric artery ascends obliquely inwards, soon reaches the outer border, and next the posterior surface of the rectus abdominis muscle, and then passes vertically upwards. Having reached the umbilicus, it penetrates into the substance of the rectus, and terminates by anastomosing with the internal mammary artery.

Relations. The relations of the transverse, oblique, and vertical portions of the epigastric artery should be examined separately. The *transverse portion* varies in length in different subjects; sometimes it is almost entirely wanting, the artery running immediately upwards; at other times, it is an inch and a half in length. This difference in length, which is of no consequence when the obturator artery arises from the internal iliac, becomes highly important when that vessel is given off from the epigastric.*

This transverse portion of the artery is directed obliquely downwards, when the epigastric arises at a certain distance above the ring.

The *oblique portion* of the epigastric artery forms the outer side of a triangle, the inner side of which is formed by the outer border of the rectus abdominis muscle, and the base by the crural arch: the epigastric constitutes the true boundary between the internal inguinal fossa, which comprises all the triangular space situated on the inner side of the vessel, and the external inguinal fossa, which comprises the space upon its outer side. The abdominal orifice of the inguinal canal is situated in the external inguinal fossa, and, consequently, to the outer side of the epigastric artery. Those inguinal herniæ which pass through the internal fossa, are called internal or direct inguinal herniæ; those which take place on the outer side of the artery are called external or oblique inguinal.

In its horizontal and oblique portions, the epigastric artery is placed between the peritoneum and the fascia transversalis. I should observe that the spermatic cord in the male, and the round ligament in the female, do not cross the epigastric artery precisely in the situation of the loop which this vessel describes, but a little above it. The axis of the inguinal canal being directed obliquely downwards and inwards, intersects at right angles the oblique portion of the artery, which slopes in the opposite direction.

In its *vertical portion*, the epigastric artery is situated between the rectus and the posterior wall of the sheath of that muscle, until near the umbilicus, where it dips into the fleshy fibres.

Collateral branches. Near its origin, or rather opposite the bend which it takes, the epigastric artery sometimes gives off the internal circumflex, which, as we shall hereafter see, generally arises from the deep femoral. It always gives off the following branches, — a *cremasteric* branch (*l, fig.* 214.), which enters the inguinal canal, runs along the fibrous sheath of the cord in the

* [If the obturator arises high up from the epigastric, it describes, before it enters the pelvis, a semicircle extending along the upper, and then the inner border of the crural ring; and, consequently, has such relations with the neck of the sac in femoral hernia, that render it almost impossible to avoid wounding the artery in dividing the stricture upwards and inwards. But if, as is much more frequently the case, it arises from near the commencement of the epigastric, or by a common trunk with it, it then descends at once into the pelvis obliquely along the outer border of the crural ring, and will have the same relation with a femoral hernia.]

male, and the round ligament in the female, and passes in the one to the coverings of the testicles, and in the other to the labia majora; a second branch, which runs along the inner portion of the femoral arch, and anastomoses with its fellow of the opposite side behind the symphysis; and lastly, a branch which crosses the horizontal ramus of the pubes at right angles, and anastomoses with the obturator. I have already stated that this small branch may be regarded as forming the trunk of the obturator, when that artery arises from the epigastric. In its oblique and vertical portions, the epigastric gives off a number of *internal* and *external ascending* branches, which pass very obliquely through the rectus abdominis, partially supply that muscle, and then pierce the anterior wall of its sheath, the internal branches near the linea alba and the external branches near the outer border of the sheath, to ramify upon the skin. These branches anastomose with the internal mammary and with the lumbar arteries.

The anastomosis of the epigastric with the internal mammary takes place only in the substance of the rectus, and by very small vessels.

The Circumflex Iliac Artery.

The *circumflex* or *posterior iliac* artery (*x*, *figs.* 199. 212.), smaller than the epigastric, arises from the outer part of the external iliac, either opposite the epigastric or a little below it. It sometimes arises from the upper part of the femoral artery: it is generally single, but occasionally double, which may be regarded as resulting from a premature division of the vessel.

It passes obliquely upwards and outwards, behind the crural arch, with which it is held in contact by a fibrous layer interposed between it and the peritoneum. Opposite the anterior superior spinous process of the ilium it divides into two branches — one is an *ascending* or *abdominal branch*, which passes upwards, in the substance of the abdominal parietes, between the transversalis and obliquus internus muscles, parallel with the epigastric artery, and terminates by anastomosing with the inferior intercostal and the lumbar arteries; the other is the *circumflex* iliac artery properly so called, which is the continuation of the vessel in direction and sometimes in size; it runs along the crest of the ilium, is at first sub-aponeurotic, or rather is contained between two layers of fascia in the cellular interval separating the transversalis from the obliquus internus, and terminates by anastomosing with the fourth lumbar artery upon the crest of the ilium.

During its course, the circumflex iliac artery gives off ascending branches which ramify in the muscles and integuments of the abdominal parietes, and descending branches which ramify in the iliac fossa, and anastomose with the iliac branches of the obturator artery.

The Femoral Artery.

The *femoral* or *crural artery* (*a a'*, *fig.* 214.) is that portion of the artery of the lower extremity which intervenes between the external iliac and popliteal arteries; it is bounded above by the crural arch, and below by the junction of the two upper thirds with the lower third of the thigh, or rather by the place where the artery passes through the tendinous ring formed by the adductor magnus.

It has been proposed to take as the lower boundary of the femoral artery the origin of the deep femoral or profunda artery, which has been correctly regarded as a terminal branch resulting from the bifurcation of the femoral artery, rather than as a collateral branch. According to this view, which has not been generally adopted, the femoral would not be more than from an inch and a half to two inches in length, and would divide into a superficial and deep femoral.

The femoral artery is directed vertically, and somewhat obliquely backwards,

so that it forms a slight angle with the external iliac, on account of the oblique inclination forwards of that vessel; and further, although it is in front of the femur above, it is placed on the inner side of it below, preparatory to becoming posterior to it in the popliteal space. A line drawn from the middle of the space between the anterior superior spinous process of the ilium and the symphysis pubis, down to the inner side of the femur, below the middle of that bone, would exactly represent its direction. The direction of the femoral artery, in respect to the femur, is such, that immediately below the femoral arch it is situated over the point of junction of the inner with the two outer thirds of the head of that bone, whilst lower down it is in relation with the inner aspect of the bone; the artery, therefore, forms an acute angle, opening upwards, with the shaft of the femur, and there is an interval of an inch to eighteen lines between the vessel and the upper part of the bone, into which instruments may be passed without wounding the artery. Advantage is taken of this fact in disarticulating the head of the femur in amputation at the hip joint.

Fig. 214.

The femoral artery, which is slightly tortuous when the thigh is flexed upon the pelvis, becomes straight when the limb is extended, and it is much stretched during forcible extension.

Relations. In front, the femoral artery lies beneath the fascia in the triangular space which is bounded on the inside by the inner border of the adductor longus; on the outside, by the sartorius; and above, by the femoral arch. Lower down, the sartorius is placed between the fascia and the artery, which is in relation, first, with the inner border, then with the posterior surface, lastly, with the outer border of that muscle: besides the fascia, a number of lymphatic glands lie between the upper part of the artery and the skin. Enlargement of one or more of these glands has been mistaken for an aneurism, and an aneurism for an enlarged gland. From these relations of the front of the femoral artery it follows, that its anterior aspect may be exposed in the whole of its extent, but that it is more superficial in the neighbourhood of the crural arch.

Behind, the femoral artery rests, first, upon the body of the pubes, or the ilio-pectineal eminence, with which it is in immediate contact in emaciated subjects, but from which it is generally separated by the contiguous borders of the psoas-iliac and the pectineus muscles. The iliac fascia separates it from the psoas-iliac muscle, so that in cases of simple psoas abscess, or congestive abscess from caries of the lumbar vertebræ, the femoral artery is situated in front of the sac of the abscess. The femoral artery is also in relation behind, with the head of the femur, lower down, with the pectineus, and then with the adductor longus. It follows, therefore, that the femoral artery may be very effectually compressed at its upper part, since it is superficially situated, and rests upon hard parts.

On the outer side, it is in relation, first, with the psoas-iliac, then with the inner border of the sartorius, and, lastly, with the vastus internus, which separates it from the inner surface of the femur.

In consequence of this relation to the bone, and also of the slight thickness of the sartorius, which separates it from the skin, the femoral artery may be

compressed against the femur from within outwards in the middle third of the thigh.

On its inner inside, it is in relation with the pectineus, the adductor longus, and afterwards with the outer border of the sartorius.

Relations of the artery with the vein and nerves. The femoral vein is situated on the inner side of the artery above, but it soon passes behind it, and, still lower down, is on its outer side. The crural nerve lies on the outer side of the artery, from which it is separated by a fibrous layer belonging to the sheath of the psoas and iliacus. The artery and nerve therefore have no immediate relation with each other; but the internal or long saphenus nerve soon runs upon the sheath of the femoral vessels, and is situated on the outside of the artery; but as the vessel is passing through the tendon of the adductor magnus, the nerve leaves it, and, lower down, escapes from under the tendon of the sartorius. The short saphenus nerve, or nerve of the internal vastus, is in relation with the outer side of the artery for a short distance; and the vessel is also crossed by another small nerve.

The sheath of the femoral vessels. The femoral artery and vein are inclosed in a proper fibrous sheath, which is constructed, as it were, in the midst of the muscles of the thigh (see APONEUROLOGY). It is therefore necessary to open this sheath, and not that of any of the surrounding muscles, in order to expose the artery.

Collateral branches. The collateral branches of the femoral are, the superficial epigastric artery, the two *external pudic* arteries, a great number of *muscular branches*, and the *deep femoral* artery.

The Superficial Epigastric Artery.

The superficial epigastric or subcutaneous abdominal artery (cut across at *b*, *fig.* 214.) is a very small, but remarkably constant, branch, which arises from the front of the femoral, and sometimes from the external pudic, immediately below the crural arch, passes vertically upwards, between the integuments and the superficial fascia, gives some branches to the inguinal lymphatic glands, and terminates in the skin, near the umbilicus (arteria ad cutem abdominis, *Haller*).

The External Pudic Arteries.

The *external pudic* or *genital arteries*, also named *scrotal*, in the male, and *vulvar* in the female, arise from the inner side of the femoral; they are two in number (*c c*, *fig.* 214.), and are named the *superior* or subcutaneous, and the *inferior* or subaponeurotic.

The *superior* or *subcutaneous* arises immediately below the crural arch, passes transversely inwards in the subcutaneous cellular tissue, and divides into two branches; a superior, which passes to the pubic eminence, and an inferior, which is distributed to the skin of the penis and scrotum in the male, and to the corresponding external labium in the female. I have seen the dorsal artery of the penis arise from this vessel.

The *inferior* or *subaponeurotic branch* arises a little below the preceding, and sometimes even from the deep femoral; it passes transversely inwards, crosses the femoral vein at right angles immediately below the point where it is joined by the saphenous vein; so that this artery is generally received in the loop described by the upper end of the saphenous vein: it soon perforates the fascia and becomes subcutaneous, and then ramifies in the scrotum in the male, and in the external labium in the female. The anastomoses of the superior and inferior external pudics, both with each other and with those of the opposite side, are so free and large, that when one of them is cut across, it becomes necessary to tie both of the cut ends of the vessel. These arteries are remarkable on account of their relations with hernial tumours.

The Muscular Arteries.

The femoral gives off a great number of muscular and cutaneous branches, which have received no particular names. One, however, is usually described as the *superficial* or *great muscular* artery, which frequently arises from the deep femoral; it passes transversely between the sartorius and the rectus femoris, and immediately divides into *ascending branches* which proceed to the iliacus, sartorius, and tensor vaginæ femoris, and into very large *descending branches*, some of which are distributed to the rectus femoris, passing in at its posterior surface, whilst others penetrate the vastus internus and vastus externus. The last mentioned branches can be traced as far as the lower part of the triceps muscle; and indeed the great muscular artery might be named the muscular artery of the triceps extensor femoris, which (*g*, *fig.* 214.) may arise from the deep femoral artery.

The Deep Femoral Artery.

The *deep femoral artery* (*profunda femoris; d d′*, *fig.* 214.) is intended to supply the muscles and integuments of the internal and posterior regions of the thigh.*

It arises from the back of the femoral, generally about one and a half or two inches below the crural arch, about half way between the pubes and the lesser trochanter, very rarely below this point, but more commonly above it. Thus the femoral often divides either about six lines below the crural arch, or immediately beneath and on a level with it, into two equal and parallel branches, of which the *external* is the deep femoral, and the *internal* the femoral properly so called. I have seen this subdivision, which bears a rather close analogy to the bifurcation of the humeral artery into the radial and ulnar in the axilla, take place above the crural arch, that is to say, in the external iliac artery. Immediately after its origin, the deep femoral passes backwards and outwards, and then vertically downwards, gradually approaching the femur; it is situated deeply behind the femoral artery, but is separated from it by the femoral and deep femoral veins; it runs parallel to the femoral artery, in front of the pectineus, and on the outer side of the vastus internus; having reached the upper border of the long adductor, it passes behind that muscle to arrive between it and the short and great adductors, perforates the latter muscle a little below the tendinous opening for the proper femoral artery, and terminates by ramifying in the biceps and semi-membranosus. Sometimes, the deep femoral perforates the adductor magnus almost immediately, and at once becomes posterior to it.

During its course, the deep femoral gives off a great number of collateral branches, which are soon expended in the adjacent muscles, and most of which are unnamed. Those that are named are the *internal* and *external circumflex* and the several *perforating* arteries.

The *internal circumflex artery* (*e*) is larger than the external, and is the first branch given off from the deep femoral; not unfrequently it arises from the femoral, and it has been seen to come from the external iliac; it almost immediately dips backwards, between the pectineus and the neck of the femur, round which it turns in the same manner as the posterior humeral circumflex artery, so that it may be ruptured in luxation of the femur inwards; it escapes backwards beneath the quadratus femoris, and terminates by dividing into ascending branches, and into internal and external descending branches.

Opposite the pectineus, it gives off the following collateral branches — one very remarkable *articular branch* ascends along the capsular ligament, enters the hip joint, passes under the ligament which converts the cotyloid notch

* It is the proper artery of the thigh, whilst the femoral itself may be regarded as the artery of the leg and foot.

into a canal, and is distributed to the synovial membrane, the adipose tissue, and the fibrous capsule of the joint: one or more anastomotic branches communicate freely with the ramifications of the obturator artery; lastly, a great number of muscular branches, some of which are very small, and pass in front of, while others which are larger run behind, the pectineus, and are distributed to the obturator externus, the pectineus, and the adductors: the largest is intended for the adductor magnus.

The *terminal branches* are as follows:—*ascending muscular branches*, some of which are external, and ramify in the glutæus maximus, whilst others are internal, and are distributed to the ischiatic attachments of the biceps, semi-tendinosus, and semi-membranosus muscles; *descending muscular branches*, which ramify upon the anterior surface of the biceps, semi-tendinosus, and semi-membranosus, upon the great sciatic nerve, and also in the small muscles situated between the pelvis and the trochanter major; *periosteal branches*, of which some ramify upon the periosteum of the trochanter, others upon the posterior surface of the neck of the femur; and, lastly, *anastomotic branches*, which pass upon the obturator, gemelli, and pyriformis muscles, and anastomose freely with the sciatic, glutæal, internal pudic, and obturator arteries, but especially with the sciatic and the obturator.

It follows, then, that the internal circumflex is an important means of communication between the internal iliac, and consequently the common iliac and the femoral; for independently of the direct anastomoses above mentioned, there are a great number of indirect communications in the substance of the muscles and upon the periosteum.

The *external* or *anterior circumflex* (*f*), smaller than the internal, sometimes arises directly from the femoral; it is often given off from the profunda by a common trunk with the great muscular artery of the triceps, and it may then be regarded as formed by the bifurcation of the profunda; it passes horizontally behind the rectus femoris, crossing in front of the psoas and iliacus, to which it gives a rather large vessel, and then divides into two branches—an *ascending muscular*, which is distributed to the glutæus minimus and to the tensor vaginæ femoris; and a *circumflex* branch, properly so called, which turns round the base of the great trochanter (*f*, *fig.* 215.), dips into the substance of the triceps, and expands into a great number of ascending branches, which anastomose with the internal circumflex upon the outer surface of the great trochanter. Not unfrequently an anastomosis is formed in front by a transverse branch between the internal and external circumflex arteries, by which the arterial circle of the hip joint is completed.

The *perforating arteries* (*r r*, *fig.* 214.) are both muscular and cutaneous, and are intended for the posterior region of the thigh; they vary in number from one to four, and are all distributed in a similar manner. They perforate the tendinous attachments of the adductor muscles to the femur, and having reached the back of the thigh, they turn horizontally round the bone, and divide into *ascending* and *descending branches*, which form a series of loops or anastomotic arches in the substance of the muscles; these loops acquire a great size in cases where the femoral has been tied after Hunter's method, *i. e.* in the middle third of the thigh.

The first perforating artery (*r*, *fig.* 215.), which is the largest, and sometimes represents two, or even the whole of the perforating arteries, passes through the great adductor about one inch below the lesser trochanter, between the horizontal and oblique fibres of the muscle; its *ascending branch* (*s*) turns round the great trochanter, and anastomoses with the internal circumflex and sciatic in the substance of the glutæus maximus; its *descending branch* (*l*) is distributed to the vastus externus, the semi-tendinosus, semi-membranosus, biceps, and adductor magnus muscles. Some branches ramify upon the great sciatic nerve.*

* The principal nutritious artery of the femur arises from the first or second perforating artery.

I have seen an inferior perforating artery arise from the femoral just where it passed through the tendon of the adductor magnus.

The terminal branch (*d′*, *fig.* 214.) of the deep femoral constitutes the last perforating artery, which is distributed in the same manner as the other arteries of that name.

The Popliteal Artery.

When the femoral artery has perforated the tendinous portion of the adductor magnus, it takes the name of the *popliteal* artery, which extends down to its division into the anterior tibial and tibio-peroneal arteries.

The popliteal artery (*o*, *figs.* 215. 217.) is the artery of the ham or popliteal space: it is bounded *above* (*p*, *fig.* 215.) by the tendinous ring formed in the adductor magnus, and *below* (*p*, *fig.* 217.) by the lower border of the popliteus muscle; at which place it is situated opposite the lower end of the upper fourth of the leg. Its length in an adult subject is about seven inches.

Fig. 215.

It passes vertically, or somewhat obliquely outwards and downwards, the direction of the artery being represented by a line extending from the inner surface of the femur to the space between its two condyles. It is tortuous when the leg is flexed upon the thigh, but it becomes straight when the leg is extended, and may be ruptured by very forcible extension. It has been proved by experiment, that extension may be carried as far as to cause laceration of the ligaments of the joint, without rupturing the artery.

Relations. It is situated deeply in the whole of its course, and it is in relation, *behind*, with the semi-membranosus above; lower down, with the popliteal fascia, from which it is separated by a layer of fat of greater or less thickness according to the prominence of the ham-string muscles; below this, with the gastrocnemius and plantaris muscles; and still lower, with the soleus. The popliteal vein lies behind and slightly to the outer side of the artery and then behind it, adhering rather firmly to it. The internal popliteal nerve also lies upon it behind, but is separated from it by a very thick layer of fat. The veins and nerves both cross the artery beneath the gastrocnemius, so as to get to the inner side of the lower portion of the vessel.

From these relations it follows, that the popliteal artery may be exposed from behind in the whole of its extent, but that it is deeper-seated below than above.

In front it is in relation, from above downwards, with the adductor magnus; with the internal surface of the femur, which appears to be expanded and become posterior, so as to support the vessel; with the knee joint with which it is in direct contact; and lastly with the popliteus muscle. The direct relation of the popliteal artery with the joint explains the facility with which it may be lacerated when its tissue has been rendered fragile from organic change, and accounts for the frequency of aneurism in this region.

On the inner side, this artery is in relation with the semi-membranosus, the inner condyle of the femur, and the inner head of the gastrocnemius.

On its outer side, it has the biceps, the outer condyle, the outer head of the gastrocnemius, and also the plantaris and soleus muscles.

Collateral branches. The popliteal artery gives off from its posterior aspect several small branches, which pass into the muscles of the ham; most of them are not named; but there are some which are distinguished as the *sural* arteries: in front it gives several arteries, named *articular*, because they surround the knee, like the collateral arteries of the elbow joint. The articular arteries are divided into *superior, middle, and inferior;* the superior and inferior would have been better named the *collateral arteries of the knee.*

The *sural arteries* (*g g, figs.* 215. 217.) are two in number, one *internal* for the inner head of the gastrocnemius, and the other *external* for the outer head of the same muscle. Arising from the back of the popliteal artery, they pass downwards and backwards, are separated frcm each other by the internal popliteal nerve, enter the anterior and internal surface of each head of the gastrocnemius a little before the two heads meet, and may be traced down to the lower part of the fleshy belly of that muscle. Generally one of their branches accompanies the external saphenous nerve from the popliteal space to the upper part of the tendo Achillis.

The *superior articular* or *collateral* arteries of the knee are divided into internal and external.

The *internal* superior articular arteries are sometimes three, but most commonly two in number, one of which arises higher than the other; their origin is subject to variety, but they are constant in their distribution. We shall distinguish them as the first and second.

The *first internal superior articular* artery, usually called the *great anastomotic artery* of the knee, is the largest of the whole; it arises opposite the point where the femoral becomes the popliteal artery, and sometimes even from the lower part of the femoral itself; it perforates the adductor magnus from behind forwards, and immediately divides into four descending branches; the first is a *muscular branch* (*i, fig.* 214.), which enters the substance of the vastus internus, passes inwards and downwards to reach the inner border of the tendon of the triceps, and opposite the base or upper border of the patella perforates the fibres of the muscle, becomes superficial, and runs transversely outwards along the base of the patella, and forms an anastomotic arch with the external superior articular artery. The second and third branches are *periosteal;* one of them passes between the triceps and the femur, with which it is in contact, and terminates above the trochlea of that bone by anastomosing (at *s*) with the external superior and the second internal superior articular arteries; while the other runs along the adductor magnus, being held down against it by a layer of fibrous tissue, and anastomoses with the second internal superior articular artery, supplying its place when that vessel is only in a rudimentary state. The fourth branch (*h*) accompanies and supplies branches to the internal saphenous nerve: it appears to be constant: it is placed under the sartorius, along which it runs, together with the internal saphenous nerve, continuing with it below that muscle.

The *second internal superior articular* artery (*h, figs.* 215. 217.) arises immediately above the inner condyle of the femur, turns round it horizontally, and divides into condyloid branches, which cover the condyles with their ramifications, and communicate partly with the first internal superior articular artery, and partly with the external superior articular artery coming from the opposite side. It also gives off a patellar branch which runs upon the borders of that bone, supplies the skin and the synovial membrane of the knee joint, and anastomoses with the internal inferior articular artery.

The *external superior articular* artery (*i, figs.* 215—217.) arises opposite the second internal superior, turns horizontally round the outer condyle of the femur, gives off some ascending *muscular* branches, which ramify in the vastus

externus, and then terminates in three *periosteal branches*. One, which is superior and transverse, turns round the lower end of the femur, and anastomoses with the corresponding branch of the second internal superior articular; another and inferior branch ramifies upon the inner condyle, and anastomoses freely by a great number of branches with the external inferior articular; the third is a more superficial branch for the patella, on the side of which bone it runs, and near its upper border gives off a transverse twig, which anastomoses on the upper border of the patella with a similar one from the internal superior articular arteries, and a descending twig, which runs along the outer border of the bone, and anastomoses with the external inferior articular artery.

The *inferior articular* or *collateral* arteries of the knee are also divided into the *internal* and the *external*. They both arise from the front of the popliteal artery, opposite the middle of the knee joint.

The *internal inferior articular* artery (*c*, *fig.* 217.) runs downwards and inwards, and having reached the internal tuberosity of the tibia, turns horizontally forwards, passes beneath the tendons of the semi-tendinosus, semi-membranosus, and gracilis muscles, and also beneath the internal lateral ligament of the knee, turns upwards upon the inner side of the anterior tuberosity of the tibia and ligamentum patellæ, describing a curve with its concavity directed upwards, and anastomoses either with the superior articular arteries or with the anterior tibial recurrent. During its course it gives off ascending and descending periosteal and osseous branches.*

The *external inferior articular* artery (*b*, *fig.* 217.) arises opposite the internal vessel, turns horizontally forwards, not upon the external tuberosity of the tibia (for this is prevented by the tibio-fibular articulation), but upon the convex borders of the external semilunar cartilage, passes beneath the tendon of the biceps and the external lateral ligament of the knee joint, and terminates by dividing into an ascending branch which runs upwards along the outer border of the patella, a descending branch which anastomoses with the anterior tibial recurrent, and a transverse branch which passes behind the ligamentum patellæ below the patella, and anastomoses with a similar branch from the internal inferior articular. The inferior articular arteries complete the arterial circle which surrounds the patella, and from which numerous branches are given off, some covering the patella by their anastomoses, and others entering the bone directly through the numerous foramina which exist upon its surface.

The *middle articular* arteries (*s*, *fig.* 215.) consist of several small branches, which arise directly from the front of the popliteal artery, or from the external inferior articular, run from behind forwards into the interior of the knee joint, and are distributed in the inter-condyloid notch to the crucial ligaments, the adipose tissue, the synovial membrane, and especially to the lower extremity of the femur, which they penetrate through the large foramina on the adjacent surface of each condyle. The middle articular artery or arteries belong, therefore, to the knee joint exclusively, and do not assist in the restoration of an impeded circulation: in this respect they differ entirely from the other articular arteries, which acquire a very considerable size when the principal trunk has been tied.

The Anterior Tibial Artery.

Opposite the lower border of the popliteus muscle, the popliteal artery divides into two branches — an anterior, named the *anterior tibial* (*a*, *fig.* 217.); and a posterior, which forms the continuation of the popliteal, and may be denominated the *tibio-peroneal trunk* (*f*). This trunk soon subdivides into the *posterior tibial* (*t*) and the *peroneal* (*k*) *arteries*.

The *anterior tibial artery* (*a*, *figs.* 216, 217.), the anterior branch of the bifurcation of the popliteal terminates opposite the dorsal annular ligament of the

* By osseous branches, I mean those which enter the bone directly, through the foramina, on the internal and external tuberosities of the tibia.

tarsus (*b*, *fig.* 216.), below which the vessel is named the *dorsal artery of the foot* (*f*). Immediately after its origin, it passes horizontally forwards, perforates the upper part of the interosseous ligament, is reflected over it, and descends vertically in front of it; having reached the lower fourth of the leg, it is directed somewhat obliquely inwards, following the direction of the external surface of the tibia, and then passes under the annular ligament, at the lower border of which, as stated, it terminates.

Fig. 216.

A line stretched from that process of the tibia, which has been described as the tubercle of the tibialis anticus (OSTEOLOGY, p. 128.), to the middle of the tibio-tarsal articulation, will indicate its direction and course.

Relations. The anterior tibial artery is situated very deeply, and yet it can be exposed at any point; it is in relation, *behind*, with the interosseous ligament in its three upper fourths, and with the tibia in its lower fourth; it lies in contact with the interosseous ligament, and is retained in its place by a layer of fibrous tissue, so that, after amputation of the leg, it retracts between these two fibrous layers, and is sometimes seized and tied with difficulty.

In front, it is covered successively by the tibialis anticus, the extensor longus digitorum, and the extensor proprius pollicis, the tendon of which crosses over it; it is placed exactly along the cellular interval between the tibialis anticus and the extensor muscles; and the incision should therefore be made along the line corresponding to that interval, in order to expose the artery when it is to be tied; lower down it is only separated from the skin by the fascia of the leg and the projecting tendon of the extensor proprius pollicis, and hence it may be compressed in this situation.

On the inner side, it is in relation with the tibialis anticus, then with the tibia, and, lastly, with the tendon of the extensor pollicis, being lodged in the same sheath.

On its outer side, it has the extensor longus digitorum, then the extensor pollicis, both of which afterwards cross over it; and, lastly, it has only the fascia of the leg: the anterior tibial nerve runs along the outer side of the artery in its whole extent.

Its *collateral branches* are very small and numerous, and are distributed to the muscles and the skin. Among them, the *anterior tibial recurrent*, and the *external* and *internal malleolar* require special notice.

The *anterior tibial recurrent* artery (*c*, *fig.* 216.) is sometimes of considerable size; it arises from the tibial, after that vessel is disengaged from the interosseous ligament, passes obliquely upwards and inwards between the tibialis anticus and the external tuberosity of the tibia, with which it is in contact, and expands into diverging, periosteal, and articular branches, some of which ascend and anastomose with the external inferior articular of the knee, whilst others pass transversely, and anastomose with the internal inferior articular. I have seen the anterior tibial recurrent, of large size, run transversely below the patella, and terminate upon the internal tuberosity of the tibia.

The *malleolar*, which would be more correctly named *articular*, arteries are divided into the *internal* and *external*.

The *internal malleolar* or *articular* artery (*d*) arises opposite the dorsal annular ligament of the tarsus, passes transversely inwards under the tendon of the tibialis anticus, and divides into two branches—a *deep*, or articular, which dips perpendicularly into the ankle joint, and is distributed to that articulation, and a *superficial* or malleolar, properly so called, which passes above the mal-

leolus, and is distributed upon it, on the inner side of the tarsus, as far as the internal plantar region, where it anastomoses with the branches of the internal plantar artery.

The *external malleolar* or *articular artery* (*l*), larger than the preceding, varies much in its origin. Thus it sometimes arises under the dorsal ligament of the tarsus, opposite the internal malleolar; it often arises from the tibial, about two or three inches above the annular ligament. Sometimes it is derived from the posterior peroneal artery, and perforates the lower part of the interosseous ligament. Lastly, and most commonly, it arises by two roots; one of which is small, but variable in size, and is derived from the peroneal, whilst the other is larger, and is given off from the anterior tibial.

These differences of origin affect the course of the artery. When it arises under the ligament of the tarsus, it passes transversely outwards, and then turns in front of the external malleolus to run forwards, resting upon the tarsus. It receives the branch from the posterior peroneal at the point where it changes its direction. In those cases where it arises higher, it passes obliquely downwards, in front of the external malleolus, and then upon the outer side of the astragalus. In all cases, the external malleolar artery runs forwards on the outer side of the cuboid bone, and forms an anastomotic arch with the dorsal artery of the tarsus. It is in contact with the bones throughout its course, and is crossed by the tendon of the extensor longus digitorum: it gives off *malleolar* branches, which ramify upon the outer surface of the external malleolus; very large *articular branches*, which dip into the tibio-tarsal articulation; and one, which I would specially notice, that enters the deep fossa between the astragalus and os calcis; and, lastly, *external calcaneal branches*, which pass under the tendons of the peroneus longus and peroneus brevis, and ramify upon the outer side of the os calcis, where they terminate by anastomosing with the peroneal artery, and with some branches of the external plantar. Several of these branches are reflected upon the upper surface of the os calcis in front of the tendo Achillis, and anastomose with branches from the posterior tibial artery.

The Dorsal Artery of the Foot.

The dorsal artery of the foot (*dorsalis pedis*; *f*, *fig.* 216.) is the continuation of the anterior tibial, which takes this name after emerging from below the dorsal annular ligament of the tarsus; it terminates in the sole of the foot, by becoming continuous with the plantar arch. Not unfrequently this artery arises by two roots, one of them being formed by the anterior tibial, which is much smaller than usual, and is, as it were, exhausted near the ankle, and the other by the peroneal, which is then very large, and perforates the lower part of the interosseous ligament. In a few rare cases the anterior tibial is entirely wanting, and is represented by some small perforating branches from the posterior tibial or the peroneal; the dorsal artery of the foot is then wholly derived from the peroneal.

The size of the dorsal artery of the foot is also subject to variety; it generally bears a direct proportion to that of the anterior tibial, which I have seen as large as the posterior tibial and peroneal arteries together, whilst it has an inverse ratio to that of the two last mentioned vessels combined.

The dorsal artery runs horizontally and directly forwards upon the dorsum of the foot, as far as the posterior extremity of the first interosseous space, at which point it bends downwards at a right angle, perforates that space like a perforating artery, and terminates by becoming continuous with the plantar arch.

The direction of the dorsal portion of this artery is marked by a line extending from the middle of the tibio-tarsal articulation to the posterior extremity of the first interosseous space.

Relations. It lies in contact with the bones of the tarsus, in which position it is retained by a layer of fibrous tissue. It is separated from the skin by the

fascia of the foot, and also anteriorly by the inner portion of the extensor brevis digitorum. It runs along the outer side of the tendon of the extensor proprius pollicis, which projects so as to raise the integuments from the vessel; it may be exposed in its entire length by cutting along the outer border of that tendon. It is not uninteresting to remark, that, under the dorsal ligament of the tarsus, this artery is situated in the same sheath as the tendon of the extensor proprius pollicis.

Its *collateral branches* are *internal* and *external.*

The *internal* branches are numerous, but are not named: they ramify upon the inner side of the tarsus, and anastomose upon the inner border of the foot, either with each other, with the internal malleolar arteries, or with the internal plantar artery. One of them may be described under the name of the *internal tarsal artery*, a branch which has a remarkable course: it passes obliquely forwards and inwards as far as the posterior extremity of the first metatarsal bone, and is sometimes continued along the inner side of that bone, to form the internal collateral artery of the great toe; at other times it is reflected under the first metatarsal bone, and anastomoses directly with the internal plantar artery, after having given off a great number of branches to the inner side of the metatarso-phalangal articulation of the great toe.

Among the *external branches* there are two which require particular description, viz. the *dorsal artery of the tarsus*, or the *external tarsal*, and the *dorsal artery of the metatarsus*, or the *metatarsal artery.*

The *external tarsal artery* (*g*) varies in its size, which almost always bears an inverse proportion to that of the external malleolar and metatarsal arteries. I have seen it as large as the dorsal artery of the foot, by the bifurcation of which vessel it appeared to be formed.

It passes transversely outwards under the extensor brevis digitorum, anastomoses freely with the external malleolar artery, and gives off the following branches: some which ramify upon the outer side of the os calcis, and anastomose with the peroneal; a branch which runs upon the cuboid bone, sometimes being so large as to be regarded the continuation of the artery, and then passes under the sole of the foot to anastomose with the external plantar; and, lastly, some branches in front, which anastomose with the metatarsal artery, the place of which vessel it sometimes partially supplies, by giving off the dorsal interosseous arteries. In one case, where the external tarsal artery was very large, it passed transversely outwards as far as the outer surface of the cuboid bone, was reflected backwards on the outer surface of the calcaneum, and there anastomosed very freely with the external malleolar and the peroneal arteries. In another case, the external tarsal artery divided into two branches, one of which ran transversely outwards and reached below the sole of the foot, whilst the other formed the dorsal interosseous artery of the fourth interosseous space.

The *metatarsal artery* (*h*) generally arises from the front of the dorsal artery of the foot, opposite the posterior extremity of the first interosseous space, sometimes by a common trunk with the external tarsal just described. According to the most regular distribution, it passes transversely outwards, opposite the posterior extremities of the several metatarsal bones, and constitutes the *dorsal arch of the metatarsus* (*i*).

Three branches given off from the convexity of this arch, which is directed forwards, are named the *dorsal interosseous arteries* (*l l*). They run along the dorsal surface of the second, third, and fourth interosseous spaces, and having arrived opposite the metatarso-phalangal articulations, divide into two collateral branches for the corresponding toes. During its course along its own interosseous space, each dorsal interosseous artery receives two perforating branches, viz. a *posterior perforating artery*, opposite the posterior extremity of the interosseous space, and an *anterior perforating*, opposite the anterior extremity of the same space. This explains the otherwise singular fact, that the dorsal interosseous arteries are increased in size opposite the posterior

and anterior extremities of their respective spaces. In some subjects, the dorsal interosseous arteries are derived exclusively from the perforating arteries.

It is not very rare to find the metatarsal and the dorsal interosseous arteries wanting; their places are then supplied by the plantar interosseous arteries.

The *dorsal interosseous artery of the first interosseous space* (*n*) is given off directly from the dorsal artery of the foot, at the point where that artery dips into the first interosseous space; it is larger than the other dorsal interosseous arteries, but is distributed in a similar manner.

The dorsal interosseous artery of the second space is also rather frequently derived directly from the dorsalis pedis.

The Tibio-peroneal Artery.

Fig. 217.

The *tibio-peroneal artery* or trunk (*f*, *fig.* 217.), the posterior branch of the bifurcation of the popliteal artery, is bounded above by the origin of the anterior tibial, and below by its subdivision into two branches, viz. the *posterior* tibial (*l*) and the *peroneal* (*k*). It is from one inch to eighteen lines in length, sometimes it is not more than six lines, and it may be two or even three inches; I have seen it extend as low as the inner part of the os calcis, where it divided into the internal and external plantar arteries.

It forms the continuation of the popliteal in regard to direction, and is in relation with the soleus behind and the muscles of the deep layer in front; the posterior tibial nerve crosses behind to get to its outer side below.

The *collateral branches* of the tibio-peroneal artery are, first, an *internal recurrent branch*, which perforates the soleus from behind forwards, turns round upon the inner border of the tibia, is reflected upwards, and anastomoses with the internal inferior articular artery upon the internal tuberosity of that bone; secondly, the *nutritious artery of the tibia* (*s*); and, lastly, a single large branch, or several branches, to the *soleus* muscle, which they enter near its peroneal attachments, and then anastomose with the anterior tibial and the external inferior articular. When the tibio-peroneal artery is short, the branch to the soleus is derived from the peroneal artery.

The Peroneal Artery.

The *peroneal artery* (*k*) extends from the bifurcation of the tibio-peroneal trunk to the os calcis. It is generally smaller than the posterior tibial, and even than the anterior tibial, and bears an inverse proportion to the size of the two, more particularly to that of the anterior tibial, the place of which it often partially supplies. In some cases it is itself replaced by some small branches derived from the posterior tibial.

It descends vertically along the posterior surface of the fibula, from which it is separated by the flexor longus pollicis; it is covered by the soleus, and dips below between the flexor longus pollicis and the tibialis posticus, to reach the

interosseous ligament, at the lower part of which it divides into a *posterior* and an *anterior* branch.

Its *collateral branches* are, first, posterior ones, which are very numerous, and supply the soleus: the highest of these are of considerable size, and often arise from the tibio-peroneal artery. Secondly, there are internal and external branches, which pass to the deep-seated muscles of the leg: amongst the external branches is the nutritious artery of the fibula; and amongst the internal branches a transverse or oblique anastomotic twig may be specially noted, which extends from the peroneal to the posterior tibial. Sometimes this anastomotic branch is very large, and, in that case, the posterior tibial is more slender than usual up to that point, but increases in size after receiving this addition, and afterwards gives off the plantar arteries.

Terminal branches. The anterior terminal branch, named the *peroneal perforating*, or the *anterior peroneal* artery (*g*, *fig.* 216.), perforates the lower part of the interosseous ligament, descends upon the lower end of the tibia, and anastomoses with the external malleolar artery, which is sometimes formed by it. This branch, which is generally very small, is sometimes as large, or even larger than the posterior branch, and then supplies the place of the lower part of the anterior tibial, and forms the dorsal artery of the foot; the anterior tibial is then very small. There almost always exists a trace of this distribution in the presence of a small branch, which anastomoses with the anterior tibial.

The *posterior terminal branch* (*l*, *fig.* 217.) of the peroneal artery, which might be called the *external calcaneal*, forms the continuation of that vessel, and gains the posterior aspect of the external malleolus, to which it is applied, after running along the outer border of the tendo Achillis, being separated from the skin by the fascia of the leg and another layer of fibrous tissue. It gives off to its inner side, opposite the posterior border of the lower end of the tibia, a transverse branch, which anastomoses with the posterior tibial artery. It then ramifies upon the outer surface of the os calcis, supplies the calcaneal attachments of the muscles of the sole of the foot, and also the skin of the heel, and anastomoses with the external malleolar and also with the external plantar artery. Some small ascending branches pass above the os calcis, and anastomose in front of the tendo Achillis with corresponding branches of the posterior tibial. I have seen the external calcaneal artery derived from the posterior tibial.

The Posterior Tibial Artery.

The *posterior tibial artery* (*t*, *fig.* 217.) is the internal branch of the bifurcation of the tibio-peroneal artery or trunk, and having entered a groove on the os calcis, beneath the internal annular ligament of the tarsus (*t*, *fig.* 218.), terminates by dividing into the *internal* (*a*) and the *external* (*b*) *plantar arteries*. It is larger than the other arteries of the leg, and is generally inversely proportioned to the anterior tibial and the peroneal. Thus, in a subject in which the anterior tibial and the dorsal artery of the foot were very large, the posterior tibial and the internal plantar were scarcely one third of their ordinary size.

The posterior tibial artery is at first directed obliquely inwards, and then vertically downwards; and it is in relation, *in front*, with the tibialis posticus; lower down, with the flexor communis digitorum, which separates it from the tibia; below that, with the posterior border of the internal malleolus, from which it is separated by the tendons of the tibialis posticus and flexor longus digitorum; still lower with the ankle joint; and, lastly, whilst under the arch of the os calcis, with the groove for the tibialis posticus. *Behind*, it is at first covered by the gastrocnemius and soleus; and in the lower third of the leg where these muscles are wanting, it is in relation with the inner border of the tendo Achillis, and is separated from the skin by two fibrous layers. The internal popliteal nerve runs along the outer side of this artery.

It follows, then, that the posterior tibial artery may be compressed and exposed in the whole of the lower third of the leg.

The *collateral branches* of the posterior tibial artery are very small, and do not require any particular description: some of them are posterior, and pass to the soleus and gastrocnemius; others are anterior, and supply the deep-seated muscles, and the periosteum of the tibia. The principal nutritious artery of the tibia, which we have stated to arise from the tibio-peroneal trunk, is often given off by the posterior tibial. Most of the lower internal branches perforate the flexor longus digitorum, turn round over the internal border of the tibia, and ramify in the periosteum and integuments. Lastly, opposite the posterior border of the lower end of the tibia, we find a small transverse branch, which anastomoses with a corresponding branch, already mentioned as arising from the peroneal artery.

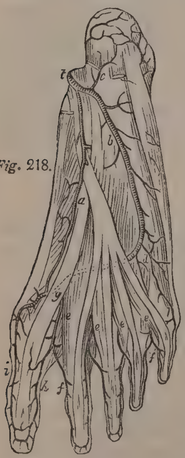
Beneath the concavity on the under surface of the os calcis, the posterior tibial gives off before its subdivision several calcaneal branches, some of which ramify upon the internal surface of the os calcis, while others mount up above that bone, and anastomose with twigs from the peroneal; also some articular branches for the tibio-tarsal and astragalo-calcaneal articulations; and lastly, some branches, which pass up upon the inner border of the tarsus, to anastomose with the internal malleolar artery.

The Internal and External Plantar Arteries.

The internal and external plantar arteries, the terminal branches of the posterior tibial, commence in the concavity beneath the os calcis, under the internal annular ligament of the tarsus.

The *internal plantar artery* (*a*, *fig.* 218.) is generally much smaller than the external; it passes horizontally forwards, along the inner side of the sole of the foot, between the abductor pollicis and the tendons of the flexor longus digitorum; more anteriorly, it is subjacent to, *i. e.* farther from the skin than, the flexor brevis digitorum; it supplies the muscles in question, gives off several ascending and oblique branches to the numerous articulations of the tarsus, anastomoses freely by some internal branches with the internal malleolar and internal tarsal arteries, and ends in different ways. The following is its most common mode of termination: having reached the posterior extremity of the first metatarsal bone, it divides into two branches; one of which is *internal*, and runs along the outer side of the abductor pollicis, and deviates a little so as to form the *internal collateral artery* (*i*) of the great toe; the other is *external*, varies much in size, and anastomoses (at *g*) with the common trunk of the collateral arteries of the first and second toe. We may regard as its terminating branch a *cutaneous artery*, which perforates the plantar fascia, and is distributed to the skin and subcutaneous cellular tissue on the inner side of the foot. I have seen the internal plantar artery very small, and terminating in the flexor brevis pollicis.

Fig. 218.



The *external plantar artery* (*b*) forms the continuation of the posterior tibial in reference to its size; but in certain cases, however, it is not larger than the internal plantar artery. It passes obliquely downwards, outwards, and forwards, accompanied by the external plantar nerve, under the os calcis, between the flexor brevis digitorum, which is below or superficial to it, and the flexor accessorius, which is above or deeper: as soon as it gains the outer border of the flexor brevis digitorum, upon the aponeurotic septum between this muscle

and the abductor of the little toe, it turns directly forwards, and having reached the under surface of the posterior extremity of the fifth metatarsal bone it changes its direction, leaves the nerve, and curves inwards and forwards, towards the posterior extremity of the first interosseous space (at *g*), where it inosculates with the dorsal artery of the foot: this curved portion of the artery, extending from the fourth to the first interosseous space, constitutes the *plantar arch*, which is formed by the junction of the dorsal artery of the foot with the external plantar artery; it runs obliquely below the posterior extremities, or sometimes the middle of the metatarsal bones, between them and the adductor of the great toe, by which, and all the other muscles of the middle plantar region, it is covered in below; and it establishes a free and uninterrupted communication between the anterior and posterior tibial arteries. I have seen the plantar arch formed exclusively by the dorsal artery of the foot, the external plantar being very small, and losing itself in the abductor and flexor brevis minimi digiti; at other times, the external plantar artery only communicates with the plantar arch by means of some small branches.

Before it constitutes the plantar arch, the external plantar artery gives off an *inferior calcaneal* branch (*c*), which passes transversely outwards, in front of the tubercles on the lower surface of the os calcis, above the flexor brevis digitorum, and terminates in the muscles of the external plantar region; also some *muscular* branches to the muscles of the external plantar region, the flexor brevis digitorum, and the flexor accessorius; and lastly, some *periosteal*, *osseous*, and *articular* branches, to the bones and to the corresponding articulations of the tarsus.

The plantar arch itself gives off superior and anterior branches. The *superior* branches, or the *posterior perforating arteries*, pass perpendicularly upwards, through the posterior extremities of the interosseous spaces, and anastomose with the dorsal interosseous arteries. There are only three posterior perforating arteries, which belong to the second, third, and fourth (*d*) interosseous spaces: the dorsal artery of the foot represents the perforating artery of the first interosseous space.

The *anterior* branches are five in number; of these, four are *plantar interosseous* or *digital arteries*, and are distinguished by the numerical names of first, second, and third, proceeding from within outwards; the fifth anterior branch is the external collateral artery of the little toe.

All the plantar interosseous or digital arteries (*e*) run forwards in the corresponding interosseous spaces, and then between two of the metatarso-phalangal articulations; opposite the anterior extremity of the metatarsal bone, each digital artery gives off a small *anterior perforating branch* (as at *s*), which anastomoses with the corresponding dorsal interosseous artery; having reached beyond the posterior extremity of the first phalanges of the toes on either side, each digital artery divides into two branches, which constitute the *internal* and *external collateral arteries* (*f*) of the corresponding toes, and are distributed in precisely the same manner as the collateral arteries of the fingers; that is to say, the internal and external collaterals of each toe anastomose by a small transverse branch opposite the second phalanx, anastomose again opposite the middle of the last phalanx, and are almost entirely distributed to the skin.

The *first plantar interosseous* or *digital artery* (arteria magna pollicis pedis) requires a special description. It is very large, and arises precisely at the point (*g*) where the dorsal artery of the foot terminates in the plantar arch, so that it appears to result from the bifurcation of the dorsal artery of the foot; it passes under the first metatarsal bone, and having arrived behind the anterior extremity of that bone, it gives off a branch from its inner side, which sometimes forms the internal collateral artery of the great toe; it then passes outwards to reach the space between the metatarso-phalangal articulations of the first and second toes, and divides into the *external collateral artery of the great toe* (*h*) and the *internal collateral artery of the second toe* (*f*). Opposite the middle of the first phalanx of the great toe, its external collateral artery gives off a

branch inwards, which anastomoses with the internal collateral artery, and sometimes even constitutes that artery.

The *external collateral artery of the little toe* (*l*), which may almost be regarded indifferently as arising from the external plantar artery, or from the plantar arch, passes forwards under the flexor brevis of the little toe, and terminates along the outer border of that toe, by anastomosing with the tarsal and metatarsal arteries derived from the dorsal artery of the foot. I have seen this branch give origin to both the external and internal collateral arteries of the little toe.

Comparison between the Arteries of the Upper and Lower Extremities.

All the arteries of the lower extremities are derived from two primitive trunks, viz. the right and left common iliac arteries, each of which soon subdivides into an internal and external iliac. The arteries for the upper extremities and head arise from three primitive trunks, the first being the brachio-cephalic, or innominate artery, which soon subdivides into the right common carotid and right subclavian; the second is the left common carotid, and the third the left subclavian, which may justly be regarded as forming together a single primitive trunk. There are then, ultimately, four trunks for the upper as well as the lower parts of the body.

The common carotid arteries, distributed as they are to the head, cannot be compared to the internal iliacs which are given to the pelvis and the organs contained in the pelvic cavity: but as the pelvis corresponds to the shoulder, we may find some analogy, if not in origin, at least in distribution, between the arteries of the one and of the other.

The external iliac corresponds to the subclavian; the more numerous collateral branches of the latter are in part represented by the branches of the internal iliac to the walls of the pelvis. Thus, the os coxæ, as well as the scapula, is as it were girdled by an arterial circle. The posterior scapular artery, which runs along the vertebral border of the scapula, represents the circumflex iliac, which turns round the crest of the ilium, and is distributed to the muscles of the abdominal parietes in the same manner as the posterior scapula is distributed to the serratus magnus and the rhomboideus. I will not carry the analogy farther, by comparing the supra-scapular, subscapular, and internal mammary arteries with the sciatic, gluteal, obturator, and internal pudic.

The axillary and brachial arteries correspond to the femoral and popliteal.

The deep humeral artery represents the deep femoral; the circumflex branches of the femoral correspond to the circumflex and subscapular branches of the axillary: the anastomoses of the femoral circumflex arteries with the obturator, gluteal, and sciatic, correspond to the anastomoses of the circumflex and subscapular branches of the axillary with the supra-scapular and posterior scapular branches of the subclavian.

The popliteal portion of the femoral represents that part of the brachial which is situated opposite the bend of the elbow; the internal and external collateral arteries derived from the brachial, together with the radial, ulnar, and interosseous recurrents, form anastomotic circles around the elbow, which are exactly analogous to those formed by the superior articular arteries given off from the popliteal with the inferior articular arteries and the anterior tibial recurrent artery.

The bifurcation of the popliteal into the anterior tibial and the tibio-peroneal trunk represents the bifurcation of the brachial into the radial and ulnar: the anterior tibial corresponds to the portion of the radial situated in the forearm; the dorsal artery of the foot to the carpal portion of the radial; and the plantar arch, which is continuous with the dorsal artery of the foot, represents the deep palmar arch, which is the continuation of the radial in the hand.

The tibio-peroneal trunk corresponds to the commencement of the ulnar artery, the posterior tibial artery to the trunk of the ulnar, and the peroneal artery to the interosseous artery of the forearm. Just as the peroneal often gives origin to the dorsal artery of the foot, so does the interosseous sometimes give off the carpal portion of the radial.

The plantar arch is represented by the deep palmar arch; the plantar interosseous and the collateral arteries of the toes, by the palmar interosseous and the collateral arteries of the fingers.

If it be asked why there is no superficial plantar arch corresponding to the superficial palmar arch, it may be said, first, that the arteries of the dorsum of the foot are much larger than those on the back of the hand; and secondly, that the hollow vaulted form of the sole of the foot preserves the plantar arch from the compression to which the palmar arch is liable, in consequence of the flattened form of the hand.*

THE VEINS.

Definition. — The venous system. — Origin of the veins. — Course. — Anastomoses and plexuses. — Varieties. — Termination. — Valves. — Structure. — Preparation. — Method of description.

The *veins* (φλὲψ) are those vessels which convey the blood back from the extremities to the heart. They are also called *les vaisseaux à sang noir*, in opposition to the arteries, which are then named *les vaisseaux à sang rouge;* but these terms are incorrectly applied, for the pulmonary veins convey red, and the pulmonary artery black blood.

There are two venous systems, corresponding to the two arterial systems, viz. the *pulmonary venous system*, through which the blood returns from the lungs to the left auricle, and the *general venous system*, which conveys the blood from all parts of the body to the right auricle. There is also a third venous system, the *system of the vena portæ*, which is an appendage of the general venous system, and, as we shall see, forms by itself a perfect circulatory apparatus. In the fœtus there is a fourth venous system, named the umbilical.

General View of the Venous System.

Both the general venous system and the pulmonary venous system, regarded as a whole, resemble the roots of a tree, the trunk of which, in the former case, would correspond to the right auricle; and, in the latter, to the left auricle. Whilst a single arterial trunk, the aorta, gives origin to the general arterial system, the corresponding veins terminate in three venous trunks, viz. the superior and inferior venæ cavæ and the coronary vein; and so in the pulmonary venous system there is a single arterial trunk, the pulmonary artery, to four veins, two for each lung.

Each artery has generally two accompanying veins, which are called its *satellite* veins (*venæ comites*), and bear the same name as the artery; besides these, there exist in some parts certain *superficial* or *subcutaneous veins*, which form a system totally apart from the arteries, and may be regarded as supplementary veins.

The *number* of the veins is, therefore, much greater than that of the arteries. This rule, however, has some exceptions; in fact, there is only one accompanying vein for the great arterial trunks, and even for some arteries of moderate size; lastly, in some few instances, there is but one vein to two arteries. Thus, there is only one superior and one inferior mesenteric, one

* [For further information concerning varieties in the distribution of arteries, the reader is referred to the "Anatomy of the Arteries, with its Applications to Pathology and Operative Surgery," by Professor R. Quain, with drawings by J. Maclise, 1841, 1842.]

renal, and one external iliac vein, each of which corresponds to the artery of the same name; but there is but one umbilical vein to two umbilical arteries, and there are several suprarenal arteries, but only one suprarenal vein.

It is impossible to estimate the size of the veins with accuracy, in consequence of the variations to which they are liable, from their extreme dilatability. Hence the very different results obtained by authors in this respect. According to Haller, the capacity of the veins is to that of the arteries as two to one; according to Borelli, as four to one; according to Sauvages, as nine to four.

The entire venous system represents a truncated cone, the apex of which corresponds to the heart, and the base to the origins of the veins. From this disproportion between the total area of the smaller veins, and the area of the trunks in which they terminate, it follows that in the course of the circulation the blood passes from a wider to a narrower space; an arrangement which tends to accelerate the progress of the fluid.

The study of the veins includes the consideration of their origin, course, anastomoses, relations, termination, and structure.

Origin of the Veins.

The veins are continuous with the arteries; a fact that is proved by the facility with which even very coarse injections will pass from the arteries to the veins, and is also most satisfactorily shown by examining the circulation in the mesentery of the frog. In some parts, instead of the communication between the arteries and veins being direct, it is established by means of an intermediate vascular network or spongy tissue, which is entirely venous: of this we have an example in the corpus cavernosum penis. Lastly, the facility with which injections forced into the veins from the trunks towards the extremities escape upon the surface of the mucous membranes, would seem to establish the fact of these vessels arising by open mouths at the surface of those membranes. Haller admitted the existence of absorbent veins arising from all the free surfaces.*

Course.

Immediately after their origin, the veins form networks, from which small branches are given off to anastomose together and form larger and larger networks: from these, again, proceed larger branches, which become successively united, just as the arteries are successively divided; that is to say, the smaller branches unite to form larger ones, and these still larger branches, which are at length united into the venous trunks. In the limbs, the veins are divided into the *superficial* and the *deep*. The *deep veins*, which accompany the arteries, have similar relations with the bones, muscles, nerves, fasciæ, and skin, as those vessels. The deep veins are always in contact with the arteries, and are contained in the same fibrous sheaths. All attempts to ascertain any law by which the relations of the veins with the arteries are regulated, have been unsuccessful. Indeed, the relative position of the two kinds of vessels, although constant, does not seem to follow any general rule. The close relations between the arteries and veins, interesting as they are to the surgeon, who is required to separate the veins carefully from an artery, before tying the latter, are no less so to the physiologist. The shock communicated to the blood in the venæ comites, by the pulsations of their corresponding artery, must assist the circulation of that fluid. In some cases of hypertrophy of the heart, I have seen the blood issue in jets from a vein, as if it were from an artery.

When, as it in some places happens, the deep veins do not accompany the arteries, there is always some special reason which observation may determine

* [The escape of injections upon mucous membranes is due to rupture or transudation; the existence of veins having open mouths upon these or other free surfaces is now denied by the best authorities.]

For example, the cerebral sinuses, which are really veins, do not accompany the arteries; nor are the hepatic veins, the ophthalmic vein, and the vena azygos, satellites of their corresponding arteries.

The *superficial veins* exist only in parts where the circulation in the deep veins is liable to be obstructed during the exercise of those parts. In fact, as the venous blood does not circulate like the arterial, under the influence of an impelling agent directly connected with them, it is retarded by the slightest cause, and hence, therefore, the necessity for additional means of circulation.

The superficial veins, therefore, constitute, in reference to the deep veins, a collateral route for the venous blood, especially during the contraction of the muscles of the upper and lower extremities, as we find in persons who exercise their limbs much. I have shewn that the tongue, as well as the extremities, is provided with a superficial and a deep set of veins. The superficial veins are situated between the investing aponeuroses of the muscles and the skin, from which they are separated by a very thin layer of fascia: they are accompanied by the subcutaneous nerves and lymphatics.

From this description it follows, that such of the deep veins as accompany the arteries do not require any special description, because they have the same distribution and the general relations as the arteries: the description of the venous system will therefore be confined to an examination of such veins as pursue a course independent of that of the arteries.

Anastomoses and Plexuses.

The *anastomoses* of the veins are more numerous than those of the arteries, and they take place by means of much larger vessels; an arrangement which compensates for the want of an impelling organ directly connected with them. Thus, anastomoses by direct inosculation, by lateral, transverse, or oblique communications, and anastomoses by convergence, are found in every situation, and with all conceivable varieties. The branches of the veins form lozenge-shaped meshes; and both the trunks and the branches communicate freely with each other; that is to say, the superficial with the deep set, the veins of the superficial set and those of the deep set amongst each other, and the vena cava superior with the vena cava inferior; so that we may say that the whole venous system forms one vascular network, and it is by these free communications that such obstacles as impede or even completely intercept the course of the blood, in a given part, are rendered incapable of stopping it altogether. In order to intercept the course of the venous blood completely, it would, in fact, be necessary to obliterate, not only the principal trunk, but also all the collateral channels. One remarkable mode of anastomosis is the following: a collateral vein arises from some point of a particular vein, and terminates at a greater or less distance in the same vein, like a canal intended to unite two distant points of the same stream: this collateral channel is intended to receive a number of veins, which would otherwise have terminated in the principal vessel. The following is a variety of this kind of anastomosis: one vein divides into two of equal size, which diverge from each other at a very acute angle, or rather run parallel, and reunite at a greater or less distance. The saphenous vein often presents this arrangement.

A *venous plexus*, which consists of a complicated network of vessels, is nothing more than the highest developement of an anastomosis: venous plexuses are found in parts where the circulation is liable to be retarded, or in organs whose functions require a large afflux of blood;—*example*, the vesical, uterine, and spermatic plexuses.

The veins are rarely tortuous, like the arteries, but are generally straight; a circumstance which also helps to lessen the effects of the deficiency of a direct impelling organ; for tortuosities, by multiplying the points of friction, would evidently retard the flow of blood in the veins. The great veins are not at all tortuous, but the smallest veins, and those forming the plexuses, are distinctly so. The tortuosities of veins are generally regarded as the result of their too

great developement. Thus hypertrophied veins, whether varicose or not, always pursue a distinctly zig-zag course.

Varieties.

The varieties in the size, the anastomoses, and the terminations of the veins are so numerous, that it is impossible to include them in any general description: it would seem that, for the due performance of its function, it matters not whether a vein terminates in one or another part of the venous system. It may be readily conceived that as the anastomoses of the veins are very numerous, and take place by very large branches, it can be of little consequence which of those anastomotic branches predominates.

Termination.

The veins of all the supra-diaphragmatic portion of the body terminate in the vena cava superior; the veins of the sub-diaphragmatic portion terminate in the vena cava inferior; the veins of the heart terminate separately in the auricle; the two venæ cavæ communicate with each other through the vena azygos, and especially through the veins of the spinal canal, so that when either of them is obliterated the other supplies its place.

Valves.

The existence of membranous folds, or *valves* (*a a*, *fig.* 218.*), in the interior of the veins is one of the most characteristic features in their structure. The existence of these valves is shown externally in injected veins by a more or less distinct knotted appearance.

Fig. 218.*

If we open, under water, a vein provided with valves, we perceive attached to its interior surface certain membranous folds, or membranous processes, as they were named by Charles Etienne, who appears to have discovered them; there are generally two, placed one opposite the other; they are rarely solitary even in the smallest vessels, and still less commonly are three found together, as Haller and Morgagni say they have observed. They all have a semilunar form, like the sigmoid valves of the aorta and pulmonary artery; their adherent border is convex, and directed towards the extremities; their free border is straight, and is directed towards the heart.

Both surfaces are free; the inferior is turned towards the centre of the vessel, whilst the superior corresponds to its sides, which always present a dilatation or sinus (*b*) opposite the valves, that gives a knotted appearance to the vein when distended: the constricted part of the vein corresponds to the adherent border of the valve, and the dilated portion to the valve itself.

As a necessary consequence of their direction, the valves permit the blood to flow from the extremities towards the heart, but prevent its course in the opposite direction: it was this anatomical fact which led Harvey to the discovery of the course of the venous blood. The valves are so long, that when two opposite ones are depressed, they almost completely close the channel of the vessel.

Notwithstanding their tenuity, the valves are extremely strong,—a fact of which we may be easily convinced by endeavouring to inject the veins in the opposite direction to that in which the blood flows through them. The perforations and notches, sometimes observed in the valves of veins, appear to me to be accidental.

The office of the valves is to prevent that retrograde movement in the course of the blood, which would otherwise occur from so many causes.

All veins are not provided with valves, and those which have them are very unequally so. It may be said that their presence and their number, their proximity, and their distance from each other, are directly influenced by the degree of opposition to the onward progress of the blood in any set of veins: thus, the valves are more numerous in the veins of the limbs where the blood flows against its own gravity than in those parts where it follows the direction of gravitation. There are no valves in the system of the vena portæ. They are generally more numerous in the deep than in the superficial veins.

We always find a pair of valves at the termination of a vein in a larger trunk. Very small veins have no valves. I shall take care to describe the number and arrangement of the valves in the principal veins.

The number of the valves is subject to many varieties. Some valves completely, and others but imperfectly intercept the course of the blood.

Structure.

In structure, a vein appears to me to resemble an artery, without its middle coat.* In fact, even by the most careful examination, we can only distinguish two coats in a vein; an *external*, called the *cellular* coat, but which I believe to be of the same nature as the *dartos*, and an *internal* coat, very thin, which is analogous to the lining membrane of the arteries, and, therefore, resembles the serous membranes. The internal membrane is the essential constituent of a vein; for the external coat may be wanting, or its place may be supplied by some other tissue: thus, in the sinuses of the dura mater, in the cells of the corpora cavernosa penis, in the substance of the walls of the uterus, and in the venous canals of bones, the place of the external membrane is supplied by the dura mater, by the fibrous parietes of the cells of the corpora cavernosa, by the tissue of the uterus itself, and by the proper substance of the bones.

The valves are formed by a fold of the internal membrane, containing some fibrous filaments, which are found especially along their adherent border.

The existence of a middle coat in the veins is admitted by authors, some of whom say it is composed of longitudinal fibres, whilst others think it consists of circular fibres; but such fibres do not in reality exist. Vesalius relates, that wishing to show them at one of his lectures, he was obliged to confess that he had never seen them, and could not find them.†

The walls of the veins are themselves supplied with small *arteries* and *veins* (*vasa vasorum*). No *nerves* have been demonstrated in them; nor do either mechanical or chemical stimuli applied to the inner membrane of the veins occasion pain.

It is rather a remarkable fact, in reference to the relations of the veins with the nerves, that nervous plexuses are never supported by veins, but, on the contrary, seem always to be separated from them. The trunk of the vena portæ is the only exception.

Preparation.

Most of the veins above a certain size may be examined without being previously injected; but injections are necessary for their minute investigation. The arrangement of the valves, which, in general, oppose the transmission of liquids from the heart towards the extremities, renders it necessary to inject a great number of veins from their extremities towards the heart. In general,

* [The walls of a vein are thinner than those of an artery; and hence the former, when cut across, does not remain patent, like the latter kind of vessel. The coats of the superficial veins are thicker than those of the deep-seated ones, especially in the lower limbs.]

† [Nevertheless, the veins have an intermediate set of fibres, constituting a thin middle coat. The external coat is thinner than that of the arteries, and consists of interlaced cellular filaments. The middle coat, differing from that of an artery, is composed of pale red filaments, like those of cellular tissue, mixed with others resembling elastic tissue: the bundles into which these filaments are collected pursue a very irregular course around the vein. The internal coat is more distinct, less brittle, and more readily detached than the corresponding arterial tissue; it consists of fine longitudinal interlacing filaments, covered with an epithelium; it is continuous with the lining membrane of the auricles.]

in order to obtain as perfect an injection as possible, it is necessary to throw in the fluid simultaneously at several points and in several directions. Thus, a pipe may be placed in the vena cava superior, into which the injection should be pushed from the heart towards the extremities; another in the upper part of the cephalic or basilic vein of the right side; a third in the dorsal vein of the left thumb; a fourth in the right femoral vein; and, lastly, one in the left internal saphenous vein. In all these vessels, excepting in the vena cava, the injection should be thrown from the extremities towards the heart.

The injection of the veins from the arteries, which was proposed by Jankius, is doubly inconvenient; first, because both veins and arteries would be coloured alike, which would make it difficult to distinguish between them; and, secondly, because we must use a very thin liquid, which would not become firm.

The most convenient injection mass is a coloured glue-size, because it sets slowly. If tallow be used, the subject must be placed in warm water.

The dissection of the veins, as well as that of the arteries, consists in separating them from surrounding parts, and preserving their relations as much as possible.

Method of Description.

In describing the veins, we may either follow the course of the blood, and trace the veins from the extremities to the heart, or we may pursue an opposite direction, and trace them from the heart to the extremities. I shall adopt a combination of the two methods; that is to say, I shall commence with the trunks, and pass in succession to the larger and then to the smaller branches; but in the particular description of each vein, I shall consider it as originating at the point most remote from, and terminating at the point nearest to, the heart.

DESCRIPTION OF THE VEINS.

THE PULMONARY VEINS.

Preparation. — Description. — Relations. — Size. — Peculiarities.

Preparation. These veins may be traced from the heart towards their terminations. The facility with which injections pass from the pulmonary arteries into the pulmonary veins should be borne in mind.

There are four pulmonary veins (*l l*, *m m*, *fig.* 171.), two for each lung, which open separately into the left auricle. Not unfrequently, however, there are five; three for the right, and two for the left lung. Sometimes the two left pulmonary veins seem to unite immediately before opening into this auricle.

The trunks of these veins, each of which corresponds to a lobe of the lung, pass out of that organ in front of the corresponding pulmonary artery. The two upper veins of the right lung generally unite into a single trunk, which descends towards the root of the lung, whilst the inferior trunk runs horizontally. In the interior of each lobule, the pulmonary veins commence from the ultimate ramifications of the pulmonary artery, and unite into a single branch, which emerges from the lobule in contact with the corresponding artery. These venous branches successively unite, so as to form a single trunk for each lobe of the lung. There are, therefore, three trunks for the right lung and two for the left; but the trunk from the middle lobe of the right lung soon unites to that from the upper lobe. The pulmonary trunk belonging to the upper lobe lies in front of that belonging to the lower lobe; it also passes obliquely downwards and outwards, while that which belongs to the lower lobe runs horizontally. These four trunks open into the four angles of the

left auricle (*n*), after having perforated the pericardium, within the cavity of which their course is exceedingly short.

Relations. In the substance of the lungs, the branches of the veins are behind, those of the arteries are in front, and the bronchia are in the middle. The larger branches of these three kinds of vessels cross each other at acute angles, but their extreme ramifications are parallel. At the root of the lung, the veins are in front, the artery is in the middle, and the bronchus behind.

In the pericardium, the anterior surface of the veins is invested by the serous layer of the pericardium. The right pulmonary veins are in relation in front with the vena cava superior, which crosses them at right angles: the left pulmonary veins are in relation with the left pulmonary artery.

It is generally said that the pulmonary artery is larger than the pulmonary veins; but it has appeared to me that the pulmonary veins are no exception to the general rule, that the veins are larger than their corresponding arteries.

Moreover, although there are two pulmonary venous trunks for each lung, by a remarkable exception, only a single vein accompanies each branch of the artery.

The pulmonary veins have no valves, even at their openings into the auricle; they carry red blood like the arteries, and hence the name *arteriæ venosæ*, by which they were designated by the ancients. Distinctly circular muscular fibres can be traced upon the portion of the pulmonary veins situated within the pericardium. The serous layer only partially invests these veins; and it is doubtful whether the fibrous layer is prolonged upon them at all.

THE VEINS OF THE HEART.

The great coronary or cardiac vein.—The small cardiac veins.

THE *cardiac* veins are divided into the great coronary vein and the small coronary veins of the heart.

The *great coronary vein* commences near the apex of the heart, at the lower part of the anterior inter-ventricular furrow, up which it runs (*e*, *fig.* 191.), gradually increasing in size; having arrived at the base of the ventricle, it turns to the left, so as to leave the anterior coronary artery, and, changing its direction, it runs along the left auriculo-ventricular furrow, becoming larger as it proceeds, and at length opens (*e*, *fig.* 192.) into the posterior and inferior part of the right auricle, near the inter-auricular septum.

The very great size of that portion of the vein which embraces the left auriculo-ventricular furrow has obtained for it the name of the *coronary venous sinus.* It almost always presents a very remarkable dilatation, or *ampulla*, before it enters the auricle. During its course, it receives a great number of branches.

Thus its vertical or ascending portion receives both superficial and deep veins, which emerge from the adjacent parts of the ventricles and their intervening septum.

Its circular portion receives some small *descending* or *auricular branches* from the left auricle, and also larger *ascending* or *ventricular branches*, which enter it at right angles: amongst the latter, we find the *vein of the left border of the heart*, which commences near the apex of the left ventricle, runs backwards, crossing obliquely over the corresponding artery, and opens, almost at a right angle, into the great coronary vein, behind the left border of the heart; secondly, two or three branches from the posterior surface of the left ventricle; and, lastly, a *posterior inter-ventricular branch*, which traverses the posterior inter-ventricular furrow, and terminates in the ampulla at the opening of the coronary vein into the right auricle. I have seen this branch terminate at once in the auricle by a distinct opening, covered or protected by the valve of the coronary vein. A small vein which runs along the posterior half of the right auriculo-ventricular furrow opens directly into the right auricle, near the ampulla of the great coronary vein: I do not know whether this small vein is constant. The great coronary vein has no valves,

excepting at its entrance into the right auricle; where the valve, however, cannot completely oppose the reflux of the blood, for the great coronary vein is always filled when an injection is thrown into the vena cava superior.

The *small* or anterior coronary veins of the heart, or small *cardiac veins* (*venæ innominatæ* of Vieussens), consist of three or four small veins, which run upon the anterior surface of the right ventricle, and open at the lower part of the right auricle. Among them we may point out one which runs along the right border of the heart, and has been called the *vein of Galen;* and also another very small one, which commences upon the infundibuliform prolongation of the right ventricle, enters the right auriculo-ventricular furrow, and opens directly into the right auricle.

It follows, then, that the small cardiac veins belong to the front of the right ventricle and auricle, or, we might even say, to the greater part of the right side of the heart; while the great coronary vein belongs to the left side of the heart, and to the remaining part of the right side.

I have already said that the *veins of Thebesius*, or *venæ minimæ*, which are described by Vieussens, Thebesius, and Lancisi, and which are said to pour their contents into all the cavities of the heart, do not exist at all, and that their supposed orifices are nothing more than culs-de-sac formed by intervals between the muscular fasciculi of the heart, and at the bottom of which an areolar structure is seen. I agree with Sénac in admitting the existence of venous openings in the right auricle only (of course excepting those of the pulmonary veins).

THE SUPERIOR, OR DESCENDING VENA CAVA AND ITS BRANCHES.

The Superior vena cava. — The Brachio-cephalic veins — the inferior thyroid — the internal mammary — the superior phrenic, the thymic, pericardiac, and mediastinal — the vertebral. — The Jugular veins, viz. the external — the anterior — and the internal. — The Encephalic Veins, and the Sinuses of the dura mater, viz. the lateral — the superior longitudinal — the straight — the superior and inferior petiosal — the cavernous — the coronary — and the anterior and posterior occipital sinuses — the conflux of the sinuses. — The Branches of origin of the jugular veins — the facial — the temporo-maxillary — the posterior auricular — the occipital — the lingual — the pharyngeal — the superior and middle thyroid — the veins of the diploe. — Summary of the distribution of the veins of the head. — The Deep veins of the upper extremity — the palmar, radial, ulnar, brachial, and axillary — the subclavian. — The Superficial veins of the upper extremity — in the hand — in the fore-arm — at the elbow — and in the arm. — General remarks on these superficial veins.

The *vena cava superior, descendens*, is the common trunk of all the veins of the upper half of the body, and very nearly corresponds to the ascending aorta in the parts to which it is distributed. It is situated to the right of the sternum, within the thorax, and hence has been named the *thoracic vena cava;* it commences immediately below the cartilage of the first rib on the right side, where it is formed by the junction of the two brachio-cephalic veins (*c c'*, *fig.* 170.), which return the blood from the whole supra-diaphragmatic portion of the body: from the point above mentioned it descends vertically, describing a slight curve, the concavity of which is turned to the left, and the convexity to the right side; it enters the pericardium, and (*d*, *fig.* 191, 193.) opens into the upper part of the right auricle (*m h*, *fig.* 193.), behind the auricula; its posterior half appears to be continuous with the corresponding part of the vena cava inferior: hence, doubtless, arose the opinion of Vesalius, that there is but one vena cava.

Its *relations*, whilst without and within the pericardium, require to be separately examined. Externally to the *pericardium*, the vena cava superior is in relation with the right lung, being separated from it, however, by the right wall

of the mediastinum and by the phrenic nerve, which is at first on the outer side, and then passes in front of the vein; on the left side, it is in relation with the arch of the aorta; in front, with the remains of the thymus gland and the cellular tissue of the mediastinum, by which it is separated from the sternum; behind, with the trachea, a great number of lymphatic glands intervening between them.

Within the pericardium the vena cava is covered by the serous layer of that membrane in its anterior three fourths: it is in immediate contact behind with the right pulmonary artery and right superior pulmonary vein; on the left side, it is merely in contact with the aorta.

The superior vena cava has no valves, either in its course or at its opening: it follows, therefore, that each contraction of the auricle is accompanied by a regurgitation of blood into the vena cava and into the branches immediately opening into it. Upon this regurgitation depends the phenomenon of venous pulsation.

The vena cava presents certain conditions in its *structure* which require special notice. It has been said that the muscular fibres of the auricle are prolonged upon it; I can state that such is not the case. The serous layer of the pericardium covers the pericardial portion of this vein, and the fibrous layer is prolonged upon that part of the vessel which is external to the pericardium.

Lastly, the relative length of the intra- and extra-pericardial portions of the vena cava is subject to much variety: sometimes the vein enters the pericardium at about the middle of its course; sometimes only a few lines from its termination in the auricle.

The *caliber* of the vena cava superior is less than that of both the brachio-cephalic trunks taken together, and also less than that of the vena cava inferior. Its length varies from two and a half to three inches.

Sometimes this vein is double: I once found in an adult two superior cavæ, opening into the right auricle, a variety which evidently depended upon the two brachio-cephalic veins not having united. This condition is normal in several animals.

Collateral veins. The vena cava superior receives no branch whilst within the pericardium, immediately before entering which it receives the *vena azygos.* The *right inferior thyroid* and *internal mammary veins*, and the small veins called *thymic*, *pericardiac*, *mediastinal*, and *right superior phrenic*, generally enter opposite the junction of the two brachio-cephalic trunks, and not into the vena cava itself.

As the vena azygos forms part of the system of spinal veins, it will be described with them.

As the other veins have a similar distribution on both sides, the description of those on the left side will apply to those of the right also.

The Brachio-cephalic Veins.

The *brachio-cephalic veins*, or *venæ innominatæ* of Meckel (*c c'*, *fig.* 170.), which are generally included in the description of the subclavian vein, correspond exactly to the brachio-cephalic or innominate artery, being formed by the union of the internal jugular vein (*d*) and the subclavian vein (*e*), properly so called, which correspond to the common carotid and the subclavian arteries.

There are two brachio-cephalic veins, one for the right (*c'*) and one for the left side (*c*); so that the arrangement of the veins of the upper half of the body is more symmetrical than that of the arteries.

The right and left venous trunks differ from each other in *length*; for as they both commence at the junction of the corresponding internal jugular and subclavian veins, opposite the sternal end of the clavicle of their own side, and terminate on the right of the median line, to form the commencement of the vena cava superior, it follows, therefore, that the right brachio-cephalic

vein must be much the shorter; it is, in fact, only from twelve to fourteen lines in length, whilst that of the left side is twice as long.

They differ also in caliber, the left brachio-cephalic trunk being much larger than the right, in consequence of receiving the internal mammary and inferior thyroid veins of its own side.

Also in *direction*, the right being almost vertical, and sloping only slightly to the left side as it descends, like the superior vena cava, which follows the very same direction; the left vein, on the contrary, is almost horizontal, and describes a curve with its concavity directed backwards; the two brachio-cephalic veins, therefore, unite at a right angle to form the vena cava.

Lastly, they have different *relations*. The concavity of the *left vein* embraces the front of the highest part of the aortic arch, and the three great arteries arising from it. It corresponds anteriorly with the sternal extremity of the left clavicle and the sterno-clavicular articulation, and runs along the upper border of the sternum. The *right vein* is situated in the right cavity of the thorax; it is parallel with, and on the outer side of, the brachio-cephalic artery, and it is in contact behind and on the right side with the right wall of the mediastinum and with the pneumogastric nerve, which are interposed between it and the apex of the lung.

The relations of the left brachio-cephalic vein with the arch of the aorta account for its obliteration in aneurism of that vessel, and its relation to the upper part of the sternum explains the venous pulse, seen so distinctly opposite the fourchette of the sternum in severe attacks of dyspnœa.

There are no valves in the interior of these veins, and hence considerable regurgitation may occur.

Collateral branches. The right brachio-cephalic vein, in some cases, receives only the vertebral vein; but most commonly the right inferior thyroid and right internal mammary veins terminate in it. The left brachio-cephalic vein always receives the above-mentioned veins of its own side, and also the *superior phrenic*, the *thymic*, and *pericardiac veins*, and often the *superior intercostal vein.* As this last forms part of the system of the vena azygos, it will be described in another place.

The Inferior Thyroid Veins.

There are two of these, viz. a *right* and a *left* inferior thyroid vein: not unfrequently there are three and even four.

The course of the inferior thyroid veins corresponds exactly with that of the inferior thyroid artery of Neubauer, when it exists. They arise from the thyroid venous plexuses, and sometimes directly from the superior thyroid vein by an anastomotic arch; they descend vertically between the trachea and the muscles of the sub-hyoid region, and terminate differently on the right and left sides, the right inferior thyroid vein terminating at the junction of the two brachio-cephalic veins, and sometimes even in the upper and anterior part of the superior vena cava, whilst the vein of the left side enters the corresponding brachio-cephalic vein.

In one case in which there were three inferior thyroid veins, the middle one ended in the superior cava, and the two lateral veins in the corresponding brachio-cephalic trunks.

These veins, moreover, present innumerable varieties in their number, course, anastomoses, and termination. One of the most curious and frequent of these varieties is that in which the right and left veins form an arch, which receives four or five parallel branches that issue from the thyroid gland.

The inferior thyroid veins are joined by the tracheal and inferior laryngeal veins, so that Winslow named them guttural or tracheal. They form, in front of the trachea, a large plexus, which it is impossible to avoid in performing tracheotomy.

The Internal Mammary Veins.

The internal mammary veins follow the same course as the arteries of that name, and receive a series of branches corresponding to those given off by the arteries, excepting in one instance, viz. the superior phrenic veins, neither of which, in general, terminates in the corresponding internal mammary.

Usually there are two veins of unequal size for each internal mammary artery, which is placed between them. The two almost always unite into a single trunk, which terminates on the right side at the junction of the two brachio-cephalic veins, or in the upper and front part of the superior cava, and on the left in the corresponding brachio-cephalic vein.

Among the veins which open into the internal mammary, I should mention the proper veins of the sternum, which form a very remarkable venous network in front of and behind each piece of that bone beneath the periosteum.

The Superior Phrenic, and the Thymic, Pericardiac, and Mediastinal Veins.

These are small veins which unite into two groups, one for the *right* side, terminating at the junction of the two brachio-cephalic veins, or at the upper and anterior part of the superior vena cava; the other for the *left*, and terminating in the left brachio-cephalic vein. The *pericardiac* and *mediastinal* veins commence upon the pericardium and the anterior mediastinum.

The *thymic* veins, which are very large in the fœtus, may still be seen in the adult and the aged, for the thymus gland is never completely absorbed.

The *superior phrenic* veins are remarkable for their length as well as for their small size; they accompany the phrenic nerve and the superior phrenic artery: the left superior phrenic vein often enters the corresponding superior intercostal vein, and, frequently, the internal mammary vein.

The Vertebral Veins.

The *vertebral vein* corresponds to the cervical portion of the artery of the same name, and like it is contained in the canal formed by the series of foramina at the base of the transverse processes of the cervical vertebræ; it opens into the brachio-cephalic vein immediately behind the internal jugular; and it is said to open occasionally into the last mentioned vein. Not unfrequently, as Eustachius remarks, this vein divides into two branches near its termination, one of which emerges with the artery, between the fifth and sixth vertebræ, whilst the other, either alone, or accompanied by a small arterial twig, escapes by the foramen of the seventh cervical vertebra. I have seen these two branches emerge, one at the foramen of the fifth, the other at that of the sixth cervical vertebra.

This vein commences in the deep muscles at the back of the neck, communicates by a large branch with the occipital vein, and sometimes receives a small branch, which passes out at the posterior condyloid foramen; it enters the canal of the transverse processes, between the occipital bone and the atlas; and whilst within this canal, it receives anterior muscular branches from the prævertebral region, posterior branches from the external spinal veins, and vertebro-spinal branches from the interior of the spinal canal. At the point where it opens into the brachio-cephalic vein, it receives a large branch, which corresponds in its course to the ascending cervical artery; it also receives the deep cervical vein, which has the same distribution as the artery of that name.

The Jugular Veins.

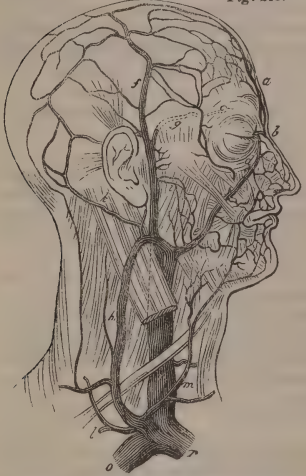
The *jugular veins* (from *jugulum*, the throat) are three in number on each side, viz. the *internal* or *deep jugular* (*n*, *fig.* 219.), the *external jugular* (*h*), and

the *anterior jugular* (*m*). The two latter veins form part of the superficial or subcutaneous venous system; but the internal jugular is the satellite vein of the common carotid artery and its branches. I shall describe these three veins in succession, but shall not notice the veins with which they are directly continuous, nor yet their branches of origin, until I have described all three of them, because those branches terminate almost indifferently in either of them.

The External Jugular Vein.

The *external jugular* (*h*), one of the supplementary veins of the internal jugular, is a subcutaneous vein of the neck, on the lateral and anterior aspect of which it is situated. It is bounded above by the angle of the lower jaw according to some authors, by the neck of the condyle of that bone according to others: the former mode of limitation seems to me to be preferable. It is bounded below by the clavicle, behind which it ends in the subclavian vein (*o*), immediately to the outer side of the internal jugular, and sometimes even opposite that vein, but upon a plane anterior to it.

Fig. 219.



The external jugular is generally *single*, but is sometimes *double*; and this depends either upon some of its branches of origin not joining it until they reach the lower part of the neck, or else upon the existence of a small collateral branch, which arises from the upper part of the *external* jugular, runs along its outer side, and opens into it below, immediately before its termination; at other times the external jugular bifurcates before it ends in the subclavian.

The external jugular varies extremely in *size*, which frequently differs on the two sides, and is not uniform throughout its whole length. Thus, it almost always presents an ampulla, or ovoid dilatation of variable dimensions near its termination. In size it is inversely as that of the other jugular veins of the same and the opposite side, and its differences are either congenital or acquired; the former depending upon the fact of its receiving more or fewer branches, whilst acquired alterations in size are occasioned either by some occupation requiring violent respiratory efforts, or by the venous circulation being impeded by disease.

Direction. The external jugular vein passes obliquely downwards and backwards in the opposite direction to the sterno-cleido-mastoideus, which it crosses at a very acute angle, and then runs parallel to the posterior border of that muscle. A line drawn from the angle of the jaw to the middle of the clavicle will exactly indicate its direction. Opposite the clavicle, the external jugular vein turns forwards and opens into the subclavian, either directly, or after running horizontally for some lines.

Relations. The external jugular vein runs first across the sterno-mastoid, and then the supra-clavicular region of the neck. In the whole of its extent it is covered and separated from the skin by the platysma; hence the rule to open this vein across the fibres of the platysma, when it is desirable that the orifice should be free, and favourably disposed for the flow of blood. By its *deep surface* it is in relation with the sterno-mastoid, which it crosses obliquely, so that it rests above upon the anterior border of that muscle, and, below,

upon its external surface, and parallel with its outer border. In the supra-clavicular region it is in relation behind with the omo-hyoid and scalenus anticus muscles and with the brachial plexus. It is always separated from these different parts by the cervical fascia, which is perforated by it as it curves forwards to enter the subclavian vein.

The external jugular vein is surrounded by the superficial nerves of the cervical plexus, some of which pass in front, and others behind it. The auricular nerve runs behind its upper portion.

This vein has generally two valves, one in the middle, the other near its termination; sometimes only the latter exists. These valves do not appear, in general, to oppose any great obstacle to an injection thrown from the heart towards the extremity of the vein.

Collateral branches. The external jugular vein receives, *in front*, branches of variable size and number, which communicate with the anterior jugular vein, and others which pass directly out of the sterno-mastoid muscle; *behind*, it receives the *superficial occipital veins* (*k*), and several superficial branches from the posterior and lateral regions of the neck; lower down, it also receives the *supra-scapular* and *posterior scapular veins* (*l*), which exactly correspond to the arteries of the same names. A constant branch passes beneath the clavicle, and establishes a communication between the external jugular vein and the upper part of the veins of the arm.

Branches of origin. These are extremely variable; most commonly the external jugular is formed by the junction of the *temporal* (*f*) and the *internal maxillary veins.* Sometimes it is formed by a branch resulting from the bifurcation of a trunk common to those two veins; at other times, by the successive junction of the *temporal, internal maxillary, facial, lingual,* and *superior laryngeal* veins.

In all cases the external communicates either directly or indirectly with the internal jugular vein in the substance of the parotid gland by means of a *communicating branch,* which may be regarded as a branch of origin, and which sometimes is the only branch of origin.

The Anterior Jugular Vein.

The *anterior jugular* is a subcutaneous vein (*m, fig.* 219.), supplementary to the external and even to the internal jugular, and collects the blood from the parts situated in the middle of the anterior region of the neck.

It varies in *size* in different individuals, is almost always inversely proportioned to the external jugular, and is often larger than that vein. We frequently find both a right and a left anterior jugular vein; but then they are rarely of equal size. Rather frequently, however, there is only one, scarcely a trace of the other existing. Lastly, instead of these veins, there are occasionally only some small branches which scarcely deserve notice.

Direction. From the supra-hyoid region, where it commmences, this vein passes vertically downwards, between the median line and the inner border of the sterno-mastoid muscle; opposite the fourchette of the sternum it bends abruptly, passes horizontally outwards behind the two lower fasciculi of the sterno-mastoid, and enters the subclavian vein on the inner side of the external jugular, sometimes opposite to but in front of the internal jugular; lastly, in other cases, it terminates by a common orifice with the external jugular.

During its course it runs in the substance of that median layer of fibrous tissue which we have called the cervical linea alba, and it receives several collateral branches.

Collateral branches. The anterior jugular veins communicate with the external by one or two branches of variable size; they also communicate freely with the internal jugular veins; the communicating branches often form the origins of this vein. The anterior jugular receives some *laryngeal branches,* and some-

times an *inferior thyroid vein.* At the point where it bends at the lower part of the neck it receives a subcutaneous vein, which comes from the upper part of the thorax, and passes above the fourchette of the sternum. At the same point, also, the right and left anterior jugular veins communicate with each other by a transverse branch (*r*, *fig.* 223.), into which branches derived from the inferior thyroid vein, or even some branches communicating directly with the left brachio-cephalic vein, pour their contents.

Branches of origin. The anterior jugular vein often commences by subcutaneous and muscular branches, derived from the supra-hyoid region, and corresponding in their several courses to the branches of the sub-mental artery. I have seen it arise from one end of a loop, the other end of which was continuous with the external jugular vein; at other times it commences by a common trunk with the facial and lingual veins. Lastly, I have seen the anterior jugular form the continuation of the facial vein.

The Internal Jugular Vein.

The *internal jugular vein* (*n*, *fig.* 219.), the principal vein of the head, collects the blood from the interior of the cranium and from the greater part of the face and neck; it commences at the posterior lacerated foramen, and terminates in the brachio-cephalic vein (*r*), which is formed by the junction of the internal jugular with the subclavian vein (*o*). Its *direction* is vertical, without any deviation or bending.

It is of considerable *size*, but varies in different individuals; it is seldom of equal size on both sides, and is inversely proportioned to the external and anterior jugular veins; it becomes extremely large in such chronic diseases as impede the entrance of blood into the cavities of the heart. I have sometimes seen the internal jugular vein of the left side very small, its place being then supplied, as in the lower animals, by a very large external jugular.

Moreover, the internal jugular is not of uniform size throughout its whole length. It commences at the posterior lacerated foramen by a dilatation, which is called the *gulf of the internal jugular vein;* it continues of the same size until opposite the larynx, where it becomes greatly enlarged in consequence of receiving several branches; it terminates below in an oblong dilatation, and is again slightly contracted as it opens into the brachio-cephalic vein. This oblong dilatation in some asthmatic persons is very large, and might be called the *sinus of the internal jugular vein.*

That part of the internal jugular vein which extends from the os hyoides to the brachio-cephalic vein represents the common carotid artery; the part included between the os hyoides and the posterior lacerated foramen represents the internal carotid; and the series of branches which terminate in it represent the external carotid and the ramifications of that artery. These branches of the internal jugular, however, do not unite into a common trunk corresponding to the trunk of the external carotid artery, so that the distribution of this vein represents very nearly that variety in the distribution of the arteries of the neck, in which there is no external carotid artery; the branches usually given from it arising from the common carotid artery, which then terminates in the internal carotid.

Relations. In that portion of its course which corresponds to the internal carotid artery, the internal jugular vein has almost the same relations as that vessel: thus it is situated in the triangular interval between the pharynx and the ramus of the lower jaw; the artery, together with the pneumogastric, hypo-glossal, glosso-pharyngeal, and spinal accessory nerves lie to the inner side and in front of it; the styloid and vaginal processes and the styloid muscles are also anterior to the internal jugular vein. That portion of the vein which represents the common carotid artery lies on the outer side of that vessel and in contact with it, excepting below, where the carotid is directed somewhat inwards to reach the arch of the aorta, whilst the vein continues to be vertical, and is therefore separated from the artery. During its course it

has the same relations as the artery, only on account of being situated to the outer side of that vessel, it follows that it is not covered by the platysma myoides to so great an extent as the artery, and therefore that it is covered for a greater length by the sterno-mastoid; and, indeed, its lower end is inclined to project beyond the outer border of that muscle, so that in asthmatic persons the skin covering the anterior part of the supra-clavicular triangle becomes elevated when the enlarged part of the vein is dilated. The pneumogastric nerve is situated behind, between the artery and the vein. A very important relation of the internal jugular vein is that which it has with the subclavian artery, which is situated between it and the vertebral vein, the internal jugular being in front and the vertebral vein behind the artery.

The internal jugular vein returns all the blood from the interior of the cranium, receiving it from the lateral sinus, which may be regarded as the origin of this vein, and as the common trunk of all the veins within the cranium. Its *collateral branches*, several of which belong sometimes to the internal, and at others to the external jugular, are the *facial* (*e*), *lingual*, *inferior pharyngeal*, *superior thyroid* (all which often open by a common trunk), and *middle thyroid* veins, sometimes also the *temporal* (*f*), *internal maxillary*, and *deep occipital* veins. We shall describe in succession the branches of origin, and then the collateral branches of the internal jugular vein.

The Encephalic Veins and the Sinuses of the Dura Mater.

The commencing twigs and the branches of the cerebral veins are like all other veins, but their trunks are essentially different, for they consist of fibrous canals, formed as it were in the substance of the dura mater; the lining membrane of these canals is the only part in which they correspond in structure with the rest of the venous system, the dura mater forming their outer coat. These canals are called the *sinuses of the dura mater*. They receive the blood from the brain, cerebellum, and medulla, from the eye, and from the bones of the cranium.

All the *sinuses of the dura mater* have a similar situation; they all occupy grooves, formed for them upon the internal surface of the bones of the cranium, and which we have already described. They are for the most part situated opposite the intervals between the great divisions of the encephalon: thus, the superior longitudinal sinus occupies the fissure between the two hemispheres of the brain; the lateral sinuses are situated opposite the great fissure, which separates the cerebrum from the cerebellum. All the sinuses communicate with each other, and form an uninterrupted series of canals; they all open into the lateral sinuses, which are to the other sinuses what venous trunks are to their branches.

There are *twelve* sinuses in all, not including the inferior longitudinal sinus, which may be regarded as a vein. Eight of the sinuses exist in pairs, the remaining four are single, and occupy the median line. The single sinuses are the *superior longitudinal sinus*, the *straight sinus*, the *coronary sinus*, and the *transverse occipital sinuses*. The eight sinuses which exist in pairs are placed four on each side of the cranium; they are the two *superior* and two *inferior petrosal*, the two *occipital* and the two *lateral sinuses*.

As the lateral sinuses form as it were the common trunks of all the others, I shall describe them first.

The Lateral Sinuses.

The *lateral* or *transverse sinuses* (*a a*, *fig*. 221.) are situated in the lateral grooves (*vide* Osteology, vol. i. p. 40.); each of them commences, like those grooves, at the internal occipital protuberance, and passes horizontally outwards, as far as the base of the petrous portion of the corresponding temporal bone; at which point it dips obliquely downwards and inwards into the inferior occipital fossa, turns round the base of the pars petrosa, and again

ascends to reach the posterior lacerated foramen of its own side (*s s*, *fig.* 221.), where it terminates in the internal jugular vein. Like the corresponding grooves, the right and left lateral sinuses are of unequal size, the right being almost always the larger. Both of them gradually increase in size from their posterior extremity, which may be regarded as their origin, to their anterior extremity.

A section of the horizontal portion of each lateral sinus, which is situated in the outer margin of the tentorium cerebelli, is triangular, whilst that of its vertical or curved portion is semi-cylindrical. In the first part of its course it projects beyond the corresponding groove in the occipital bone, so as to occupy the fissure between the cerebrum and cerebellum. In the remainder of its course it does not project into the interior of the cranium, or pass beyond the groove which is exactly suited to its dimensions.

The internal surface of each lateral sinus is smooth; and it is not traversed by bands like those found in the other sinuses. However, I once found in the the horizontal portion of this sinus some of the white bodies called glandulæ Pacchioni.

One of the lateral sinuses has been found divided, in front, into two equal parts, a superior and inferior, by a perfect horizontal septum; it is very common to find a fibrous lamina indicating a trace of this subdivision.

The anterior extremity of each lateral sinus is continuous with the gulf of the corresponding internal jugular vein, and the inferior petrosal sinus of its own side opens into it at the same point. During its course it receives some *inferior cerebral veins*, some *cerebellar veins*, and the *superior petrosal sinus* (*f*), which enters it at the point where it changes its direction from horizontal to oblique, *i. e.* opposite the base of the petrous portion of the temporal bone.

The *lateral and inferior cerebral veins* commence partly on the lateral and inferior parts of the convex surface of the cerebrum, and partly on the base of the brain; they unite so as to form a group of three, four, or five veins, which open into the horizontal portion of the lateral sinus. They enter from before backwards, that is to say, in an opposite direction to the course of the blood in the sinus. One of these veins is sometimes observed to run along the tentorium cerebelli, with which it is maintained in contact by the parietal layer of the arachnoid, for about an inch before it opens into the lateral sinus.

The *lateral and inferior cerebellar veins* are very large; they commence upon the lower surface of the cerebellum, and terminate in two or three trunks, which are found upon the circumference of the cerebellum, and open into the horizontal portion of the lateral sinus by perforating its lower wall.

A *large mastoid vein*, which may be regarded as one of the principal origins of the occipital, also opens into the lateral sinus, and thus establishes a free and direct communication between the venous system within and that outside the cranium.

The Superior Longitudinal Sinus.

The *superior longitudinal sinus* (*b b*, *fig.* 220.) is a single and median sinus, which occupies the longitudinal groove, and accordingly extends from the crista galli to the internal occipital protuberance; it is formed within the substance of the convex border of the falx cerebri, and is three sided; a section of it represents an isosceles triangle (*b*, *fig.* 221.), with its base turned upwards and its apex downwards. It is small at its anterior extremity, but gradually increases in size as it approaches the confluence of the sinuses (*n*, *fig.* 221.) in which it terminates. It not unfrequently bifur-

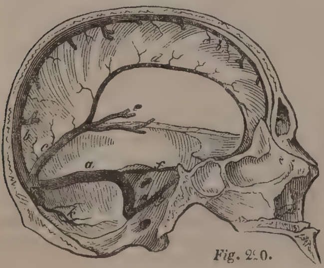


Fig. 220.

cates near its posterior extremity; sometimes it is directly continuous with the right lateral sinus.

The internal surface of this sinus is remarkable for the transverse bands found in it, especially along its inferior angle. These bands consist of fibrous tissue covered by the lining membrane of the sinus; and they conceal the orifices of the veins which open into it; in some points they are so numerous as to form an areolar tissue. Lastly, we almost always find on the internal surface of the sinus some small white projecting bodies, the *glandulæ Pacchioni.*

The following veins open into the superior longitudinal sinus: some from the internal or flat surface of each cerebral hemisphere, called the *internal cerebral veins;* others from the upper half of the convex surface of the brain, or the *external cerebral;* and lastly several veins from the dura mater and the bones of the cranium.

The *internal cerebral veins*, three or four in number on each side, return the blood from all the convolutions of the flat surface of the corresponding hemisphere of the brain, and enter the superior cerebral veins at the point where these are applied to the surface of the falx.

The *superior cerebral veins* vary in number, but are generally seven or eight on each side. The anterior of these veins are very small; the posterior are much larger. There is almost always one of greater size than the rest, which may be named the *great superior cerebral vein:* it appears to commence in and run along the fissure of Sylvius, is then prolonged obliquely backwards, and turning forwards upon the convex surface of the brain, so as to describe a curve having its concavity directed forwards, it becomes applied to the falx cerebri, and opens into the longitudinal sinus, after having run for about one inch in the substance of its walls. During its course this vein receives a great number of branches, some anterior and others posterior, which, although corresponding to the arteries in their origin and in a part of their course, are completely separated from those vessels at their termination. The common trunks pass inwards towards the great median fissure of the brain; near the sinus they become attached to the dura mater, being held down by the arachnoid membrane, which is reflected from the brain upon the dura mater; they then change their direction, turn forwards in the substance of the falx cerebri, beneath a very thin layer of the dura mater, and after a course of from six to ten lines in length, terminate in the longitudinal sinus by one or more openings. The manner in which the cerebral veins open into the sinus varies: for some there are lateral openings, as if made by a punch; others open by means of an areolar fibrous tissue, which, as I have already stated, is found in certain parts of the walls of the sinuses. All the venous orifices are concealed by fibrous areolæ, none of the veins opening directly into the sinus. Most of them run for a certain distance from behind forwards, *i. e.* in an opposite direction to the course of the blood, before they open into the sinus; the most anterior veins, which run from before backwards, are the only exceptions to this rule, Moreover, the fold or bands which are formed in this and other sinuses do not perform the functions of valves, for they permit fluids to pass from the sinus into the veins. The inferences drawn by physiologists from the direction in which the cerebral veins open into the sinuses, appear to me to be erroneous, for that direction facilitates, instead of opposing the reflux of the blood. I have satisfied myself that the cerebral veins have no valves in any part of their extent.

The superior longitudinal sinus also receives *proper veins from the dura mater*, some *venous* or *diploic* veins, and several veins which commence in the pericranium, and establish a communication between the external and internal veins of the cranium. Among the communicating veins are those which traverse the parietal foramina, and are called the *veins of Santorini.* A very great number of veins penetrate through the longitudinal suture, to open into the corresponding sinus in young subjects; the communication of the

diploic veins with those of the dura mater, and with the sinuses and cerebral veins, may be shown by perforating with a pin, in a young subject, the very thin and brittle external bony table which covers one of the numerous veins of the diploe, and then inserting into the orifice the fine point of a mercurial injecting apparatus: the mercury will fill the diploic veins, and will pass into the sinuses, the veins of the dura mater, and the cerebral veins.

The Straight Sinus.

The *stright sinus* (*c*, *fig.* 220.) occupies the base of the falx cerebri, corresponding with the line of junction of the falx with the tentorium cerebelli.

The straight sinus is therefore single and situated in the median line; it is directed somewhat obliquely backwards and downwards, and it opens into the confluence of the sinuses, or torcular Herophili (*n*), by one or sometimes two orifices, according to the presence or absence of a vertical band across its termination. It is three sided, and a section of it represents an isosceles triangle (*c*, *fig.* 221.), having its base turned downwards. This sinus increases in size as it proceeds backwards.

The straight sinus receives by its anterior extremity the *inferior longitudinal vein* or *sinus*, the *two great ventricular veins* or *venæ Galeni*, the *inferior median cerebral veins*, and the *superior median cerebellar vein*.

The *inferior longitudinal vein* (*d*), which is generally but incorrectly described as the *inferior longitudinal sinus*, may be regarded as an ordinary vein inclosed within the posterior half of the free margin of the falx cerebri. This vein increases in size from before backwards, and enters directly into the straight sinus. It sometimes bifurcates before its termination, and then the lower branch of the bifurcation opens into the anterior extremity of the straight sinus, and the upper describes a decided curve, and enters at the middle of that sinus.

The inferior longitudinal vein receives the *proper veins of the falx cerebri*. It seldom receives any vein belonging to the brain itself.

The *ventricular veins*, or *venæ Galeni* (*e*), are two in number, one proceeding from the left, and one from the right lateral ventricle. Each of them is formed by the union of two branches, viz. the *choroid vein* and the *vein of the corpus striatum.*

The *choroid vein* runs along the whole length of the outer border of the choroid plexus, in a direction from behind forwards. During this course it receives the vein from the hippocampus major, one from the fornix, and one from the corpus callosum, and having reached the anterior extremity of the choroid plexus, it turns back again within the substance of the plexus, and unites with the vein of the corpus striatum.

The *vein of the corpus striatum* is much smaller than the preceding; it commences behind in the furrow between the corpus striatum and the thalamus opticus, traverses the whole length of that furrow, covered by the tænia semicircularis, receives, during its course, a great number of small veins from the corpus striatum and thalamus opticus, and having arrived behind the anterior pillar of the fornix unites with the choroid vein to form one of the venæ Galeni.

The two *venæ Galeni* proceed parallel with each other, and horizontally backwards beneath the velum interpositum, pass out from the brain beneath the corpus callosum, and immediately enter the straight sinus below the opening of the inferior longitudinal vein without crossing each other, as is stated by some anatomists.

Not unfrequently we find an anterior and superior cerebellar vein opening into the venæ Galeni, as the latter enter the straight sinus.

The *inferior median cerebral veins* are very large. One is anterior, and commences upon the fore part of the lower surface of the cerebrum, and turns round its corresponding crus; whilst the other, which is posterior, arises upon

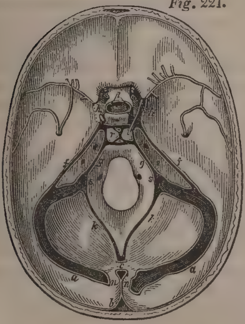
the posterior convolutions: they both enter the anterior extremity of the straight sinus, behind the venæ Galeni.

The *superior median cerebellar vein* passes upwards between the valve of Vieussens and the superior vermiform process, and opens into the anterior extremity of the straight sinus.

The Superior Petrosal Sinuses.

The *superior petrosal sinuses* (*f f*, *fig.* 221.) are situated along the upper border of the petrous portion of the temporal bones, and are partly lodged in the small corresponding grooves; they are continuous as regards their direction with the horizontal portion of each lateral sinus, and occupy the anterior half of the lateral or adherent borders of the tentorium, the lateral sinuses occupying the posterior half. They are very small, and, like the part of the lateral sinus with which they are continuous, they are three sided. The anterior extremity of each superior petrosal sinus communicates with the corresponding cavernous sinus (*h h*); and its posterior extremity opens into the corresponding lateral sinus at the point where the latter leaves the tentorium cerebelli to turn round the base of the petrous portion of the temporal bone.

Fig. 221.



The superior petrosal sinuses, therefore, establish a direct communication between the cavernous and the lateral sinuses; they sometimes receive an *inferior lateral cerebral vein*, but always an *anterior lateral cerebellar vein*, which passes upwards under the free margin of the tentorium cerebelli behind the fifth pair of nerves. The veins which come from the sides of the pons Varolii also enter the anterior extremity of this sinus.

The Inferior Petrosal Sinuses.

The *inferior petrosal sinuses* (*g g*) are situated, one on each side, upon the petro-occipital sutures, and lie in corresponding grooves; each of them extends from the anterior to the posterior lacerated foramen of its own side. They are larger than the superior petrosal sinuses, and are semi-cylindrical, like the anterior part of the lateral sinuses with which they are continuous. The anterior extremity of each opens into the anterior occipital sinus (*r*) and into the cavernous sinus of its own side; whilst its posterior extremity opens into the anterior end of the corresponding lateral sinus, opposite the commencement of the internal jugular vein (*s*). These sinuses establish a free anastomosis between the anterior and posterior sinuses found at the base of the cranium.

Excepting one vein which comes from the base of the cranium through the foramen lacerum anticus, the inferior petrosal sinus receives no vein of importance.

The Cavernous Sinuses.

The *cavernous sinuses* (*h h*), so named from their reticulated, and as it were spongy structure, occupy the sides of the sella turcica and the grooves on the body of the sphenoid bone. Each cavernous sinus is bounded in front by the inner part of the sphenoidal fissure, and behind by the apex of the petrous portion of the temporal bone: its cavity (shown on the right side in the

figure) is larger than it at first sight appears to be, but is encroached upon by the internal carotid artery, which curves twice upon itself during its passage through the sinus, and also by the abducens oculi, or sixth cranial nerve. The motor oculi or third nerve, the trochlearis or fourth, and the ophthalmic branch of the fifth cranial nerve, are situated in the substance of the outer wall of the sinus. It is traversed by reddish reticulated filaments, the nature of which is unknown. The older anatomists said, that the internal carotid artery and the sixth nerve were bathed in the blood of the sinus; but it is now generally believed, in accordance with the opinion of Bichat, that they are protected by the lining membrane of the veins; it is difficult to prove the accuracy of this opinion, although analogy is in its favour. Bichat also thought that the reticulated filaments mentioned above were folds of the lining membrane of the vein. The anterior extremity of each cavernous sinus has been named the *ophthalmic sinus*, doubtless on account of its being prolonged outward. Its posterior extremity opens into the corresponding superior and inferior petrosal sinuses, and into the transverse occipital sinus. On the inner side it receives the coronary sinus, which establishes a direct communication between the right and left cavernous sinuses. Lastly, each cavernous sinus receives below several branches, which connect the veins within with those outside the base of the cranium, more particularly with the pterygoid venous plexuses.

The cavernous sinuses receive in front the *inferior* and *anterior cerebral veins*, which commence upon the lower surface of the anterior lobe of the cerebrum. The largest of these veins on each side reaches the sphenoidal fissure, turns backwards over the lateral and middle fossa of the base of the cranium, and enters the middle meningeal vein. Several anatomists state that they have seen the middle meningeal veins open into the cavernous sinuses.

Lastly, the anterior extremity of each of these sinuses receives the ophthalmic vein.

The *ophthalmic vein* is a very large vessel, which commences on the inner side of the orbit as a continuation of the *frontal vein*, and terminates by opening into the anterior extremity of the corresponding cavernous sinus; and it thus establishes a very free communication between the veins of the interior and exterior of the cranium. It pursues the same course as the ophthalmic artery but without any windings, and receives venous branches corresponding to the ramifications of that artery. Among them, I shall mention particularly the *ciliary veins*, which commence in the choroid membrane of the eye, where they are called *vasa vorticosa*, on account of being arranged in whirls.

The Coronary Sinus.

The *coronary sinus*, or *circular sinus of Ridley* (*i*), runs round the margin of the pituitary fossa, and completely surrounds the pituitary body. Its posterior is much larger than its anterior half. In old subjects it is not rare to find the quadrilateral plate of the sphenoid bone behind the pituitary fossa worn away, as if corroded by the blood of the sinus, so that it may easily be broken. At this period of life, the coronary sinus is larger than in young subjects, and extends under the pituitary body itself.

The coronary sinus only receives osseous veins from the sphenoïd, some veins from the dura mater, and those from the pituitary body. It opens freely on each side into the cavernous sinuses, which thus communicate with each other.

The Anterior Occipital, or the Basilar Sinus.

The *anterior* or *transverse occipital sinus* (*r*) is median and single; it extends transversely across the basilar groove from the foramen lacerum posticus of one side to that of the other; it is of an irregular form, much larger in the

aged than in adult and young subjects, and connects the superior and inferior petrosal sinuses and the cavernous sinus of one side with the corresponding sinuses of the opposite side. In old subjects, the basilar surface not unfrequently appears as if corroded opposite this sinus, the cavity of which often presents a cellular or spongy structure.

The Posterior Occipital Sinuses.

These (*k k*) are the smallest of all the sinuses of the dura mater: they commence one at each foramen lacerum posticus, pass from thence upon each side of the foramen magnum, converge towards the falx cerebelli, enter its substance, and open separately into the confluence of the sinuses: they receive some small veins from the bones of the cranium and from the dura mater: the posterior occipital sinuses may be said to represent the chord of the arc formed by the lateral sinuses.*

The Confluences of the Sinuses.

From what has been stated above, it appears that there are three central points in which all the sinuses meet; one situated behind and in the middle line, and one on each side of the middle line in front. The term *confluence of the sinuses* might be applied to all three points, but it has hitherto been confined to the posterior and median central point, or occipital confluence. All the sinuses open directly into one of these three points, the inferior longitudinal, if it be considered a sinus, forming the only exception.

The posterior or occipital confluence, or torcular Herophili. If that portion of the dura mater which corresponds to the occipital protuberance be opened from behind, six orifices will be exposed to view, viz. a superior, which belongs to the superior longitudinal sinus; an anterior, sometimes divided into two by a vertical band, which belongs to the straight sinus; two lateral orifices, which belong to the two lateral sinuses; and two inferior, which belong to the posterior occipital sinuses. The point at which these sinuses meet is named the *torcular Herophili* (*n n*, *figs.* 220, 221.), because it is supposed that the columns of blood flowing from the different sinuses must, in some degree, press against each other.

The anterior or petro-sphenoidal confluence. Between the apex of the petrous portion of the temporal bone and the sphenoid bone, there is on each side another confluence, at which a great number of sinuses meet, viz. in front, the cavernous sinus and the coronary sinus; on the inside, the transverse occipital sinus; and behind, the superior and inferior petrosal sinuses.

The Branches of Origin of the Jugular Veins.

The Facial Vein.

The *facial*, or *external maxillary vein* (*e*, *fig.* 219.), represents the artery of the same name; also the terminal divisions of the ophthalmic artery; and lastly, some of the branches of the internal maxillary artery.

It commences in the frontal region, where it is called the *frontal vein;* at the inner angle of the eye it is named the *angular vein;* and afterwards the *facial vein* until its termination.

The *frontal vein*, (la vein préparate; *a*, *fig.* 219.), is a subcutaneous vein, which was selected by the ancients for phlebotomy: it is sometimes single, and is then placed in the median line; but there are generally two frontal veins united by a transverse anastomosis. Among the numerous varieties

* [They sometimes join the lateral sinuses in front, as shown in the figure.]

which this vein presents, I shall point out one in which the two frontal veins are united into a single trunk, which bifurcates above the root of the nose. These veins do not exactly follow the course of the frontal arteries; they descend from the vertex, where, by their numerous anastomoses, either with each other or with the temporal veins, they form a venous plexus large enough to cover the whole frontal region. They open into a transverse venous arch, having its concavity directed downwards; it is sometimes tortuous: it is situated at the root of the nose, and is named the *nasal arch* (*b*). This arch is also joined by the *supra-orbital vein*, a deep-seated vessel (indicated by the dotted lines *c*), which runs transversely along the upper part of the orbit, receives the superior internal palpebral vein, and opens into the extremity of the arch, on the outer side of the frontal vein: the *ophthalmic vein* also terminates in the nasal arch of the vein, between which and the cavernous sinus it establishes a free communication. Thus the upper parts of the face, more particularly the eye and its appendages, are intimately connected with the brain through the medium of the veins as well as of the arteries. Moreover, the *dorsal veins of the nose*, which run on each side of the ridge of that organ, open into the concavity of the nasal arch.

The *angular veins* are given off from the right and left extremities of the nasal arch, and may be regarded as the continuations of the frontal veins; like the corresponding arteries, each of them (*d*) is situated in the furrow between the nose and the cheek. The *inferior palpebral vein* and the *vein of the lachrymal sac and nasal duct* enter the outer side of each angular vein, which is joined on its inner side by the veins of the corresponding ala of the nose.

The *veins of the ala nasi* form a very dense network between the cartilage and the skin, and also between the cartilage and the mucous membrane: from these networks, two branches are given off; a superior, which runs along the convex border; and an inferior, which runs along the lower border of the inferior lateral cartilage, or the cartilage of the ala. These two branches unite into a very large common trunk, which passes upwards, often very obliquely, into the angular vein.

The *facial vein* (*e*) commences in the angular vein, at the point where the latter is joined by the veins of the nose; it proceeds very obliquely downwards and outwards, passes under the great zygomatic muscle, reaches and then runs along the anterior border of the masseter, crosses at right angles over the base of the jaw, is received into a groove in the submaxillary gland, and terminates in several different modes.

Most commonly it unites with the lingual to form a common trunk, which enters the internal jugular; it is into this common trunk of the facial and lingual veins that the superior thyroid and the pharyngeal vein, and the common trunk of the temporal and internal maxillary veins sometimes open. In other cases the facial vein passes obliquely across the outer surface of the sterno-mastoideus, and enters at some point of the external jugular vein. I have seen it directly continuous with the anterior jugular, also with the external jugular of the same or of the opposite side, or it may enter the convexity of an arch of communication between the external and anterior jugular veins.

Collateral branches. During its course the facial vein is joined on its *outer side* by the *alveolar venous trunk*, which is very large, and may be regarded as the deep branch of origin of the facial vein, which, in fact, becomes much larger, sometimes even twice as large after its reception. This alveolar trunk commences in a very remarkable venous plexus, named the *alveolar plexus*, in which the *alveolar veins properly so called*, together with the *infra-orbital*, *superior palatine*, *vidian*, and *spheno-palatine veins* terminate, and which communicates with the pterygoid plexus. All these veins accompany the branches of the internal maxillary artery having the same names. From the alveolar plexus the alveolar trunk runs forwards and downwards below the malar bone, and unites obliquely with the facial vein. The facial is also joined on

its *inner* side by the *superior* and *inferior coronary* veins of the lip, which are distributed like the arteries, but are not tortuous; by the *buccal* vein or veins; and by the *anterior masseteric veins.*

Below the base of the jaw, the facial vein is joined by the *submental* vein; by the *inferior palatine*, which is remarkable for the *plexus* around the tonsils, which is formed almost entirely by it; also by the vein or veins from the *submaxillary gland*, and sometimes by the *ranine vein.*

During its course the facial vein is in general more superficial than the facial artery, and does not accompany it on the face, but is situated more to the outside, and is not tortuous.

The Temporo-maxillary Vein.

The *temporo-maxillary vein* or venous *trunk*, represents the temporal artery, a part of the internal maxillary, and the upper part of the external carotid: many authors follow Walther in naming it the *posterior facial vein*, in contradistinction to the facial vein properly so called, which they name the *anterior facial.* The temporo-maxillary is formed by the junction of the temporal and internal maxillary veins: it most frequently terminates in the *external jugular* vein.

The temporal vein. This vein commences above by superficial, middle, and deep branches.

The *superficial temporal veins* (*f*, *fig.* 219.) commence upon the crown of the head by *anterior* or *frontal branches*, which communicate freely with the origin of the frontal vein, by *middle* or *parietal* branches, which communicate with the corresponding branches of the opposite side, and by *posterior* or *occipital* branches, which communicate with the branches of the occipital vein. These form a very open network over the greater part of the cranium. From this network anterior and posterior branches arise, and unite with each other above or opposite to the zygomatic arch. During this course the veins do not exactly follow the direction of the corresponding arteries. It might be said that the veins of the scalp partake of the characters both of the venæ comites and the subcutaneous veins. These venous networks are moreover situated in the substance of the hairy scalp, and like the arteries are placed between the skin and the occipito-frontalis muscle.

The *middle temporal vein* is a very large vessel, often much larger than the common trunk of the superficial veins. It is situated (as indicated by the dotted lines, *g*, *fig.* 219.), beneath the temporal fascia, between it and the temporal muscle. It is sometimes formed principally by the junction of the *palpebral* with the *external orbital veins*, which, corresponding in their distribution to the arteries of the same name, unite into a common trunk that runs backwards at first between the two layers of the temporal fascia, then between the muscle and the fascia, is directed backwards and downwards, again perforates the fascia from within outwards above the antero-posterior root of the zygomatic process, and unites with the superficial temporal vein in front of the external auditory meatus.

The trunk resulting from the junction of the superficial temporal and middle temporal veins passes vertically downwards, between the external auditory meatus and the temporo-maxillary articulation, dips into the substance of the parotid gland, and having arrived behind the neck of the condyle, receives the internal maxillary vein, which constitutes the deep origin of the temporo-maxillary trunk.

The internal maxillary vein. This vein, the deep origin of the temporo-maxillary trunk, is called by Meckel the *internal* and *posterior maxillary*, in opposition to the *alveolar* branch of the facial vein, which he calls the *internal* and *anterior maxillary*: it corresponds to all the branches given off from the internal maxillary artery behind the neck of the condyle, in the zygomato-maxillary fossa; whilst the alveolar vein, the deep branch of the facial, corresponds

to all the branches given off by the internal maxillary artery upon the tuberosity of the superior maxilla and in the pterygo-maxillary fossa.

Thus it is joined by the *middle meningeal veins.* The venæ comites of the middle meningeal artery, the existence of which has been erroneously denied, are two in number, and are situated, one in front, the other behind the artery. These veins often receive some inferior and anterior cerebral veins, which enter them near the foramen spinosum of the sphenoid; they always receive veins from the bones of the cranium and from the dura mater, and communicate with the superior longitudinal sinus; they are sometimes so large, especially the anterior branch, that they have deep grooves formed for them upon the sphenoidal fossa, reaching from the foramen spinosum to the point of the great ala of the sphenoid bone. Lastly, the distribution of the middle meningeal veins is similar to that of the corresponding artery.

The internal maxillary vein is also joined by the *inferior dental*, by the *deep temporal*, by the *pterygoid*, and by the *posterior masseteric veins.* All of these veins communicate with a very large and important venous plexus, the *pterygoid* plexus, situated between the temporal and external pterygoid muscles and between the two pterygoid muscles. In this plexus, which communicates freely with the alveolar plexus, so freely indeed that they may be regarded as forming but a single plexus, the internal maxillary vein commences and joins the temporal vein, behind the neck of the condyle of the lower jaw.

The temporo-maxillary trunk, thus formed by the junction of the temporal with the internal maxillary vein, is much larger than the former vein, and continues its course through the substance of the parotid gland; it is joined directly by some *parotid veins*, by the *posterior* and *anterior auricular veins*, and lastly by the *transverse veins of the face.* The last named veins form, between the parotid gland and the masseter muscle (*i*, *fig.* 219.), between that muscle and the ramus of the lower jaw and around the temporo-maxillary articulation, a very large plexus, named the *masseteric plexus*, which communicates freely with the pterygoid plexus through the sigmoid notch.

Termination of the temporo-maxillary trunk. Most commonly the temporo-maxillary vein or trunk terminates directly in the *external jugular vein* (*h*); at other times it enters the internal jugular, and then there is merely a trace of the external jugular, which is formed principally by the superficial branches of the occipital vein, and by some communicating branches from the anterior jugular. In some cases the temporo-maxillary vein is almost equally divided between the internal and external jugulars; lastly, it is sometimes united to the lingual and the facial vein: when it ends in the external jugular, it sends to the internal jugular a large communicating branch which passes above the digastric muscle.

The Posterior Auricular Vein.

The *posterior auricular vein* follows the distribution of the artery of that name; it receives the *stylo-mastoid vein*, and enters the external jugular, or rather the temporo-maxillary vein, which does not take the name of external jugular until after it is joined by this vein.

The Occipital Vein.

The *occipital vein* is distributed in the same manner as the occipital artery; it commences at the back of the cranium, passes beneath the splenius muscle, and is joined opposite the mastoid process by one or more large *mastoid veins*, which come from the corresponding lateral sinus, establishing a direct and free communication between the venous circulation in the interior and exterior of the cranium. It was this that led Morgagni to prefer the occipital veins for the purpose of bloodletting in apoplexy. The occipital vein ends in the internal, and sometimes in the external jugular.

The Lingual Veins.

The *lingual veins*, being intended for a contractile organ, the circulation in which is on that account liable to be much interfered with, are divided, like the veins of the limbs, into the *superficial* or *submucous* and the *deep veins*.

The *superficial veins of the dorsum of the tongue*, which are generally named the *lingual* veins, occupy the dorsal region of the tongue, ramifying in a remarkable manner between the mucous membrane and the muscular fibres of that organ: all these veins open into a *dorsal* or *superior lingual plexus*, which is situated at the base of the tongue, and is joined by a great number of veins from the tonsils and epiglottis.

The *satellite vein of the lingual nerve* emanates from this plexus, accompanies the lingual nerve, receives some branches from the sublingual glands and the tissue of the tongue, and enters the facial or the pharyngeal vein, or terminates directly in the external jugular, communicating freely with the ranine veins.

The *ranine veins* are the superficial veins of the lower surface of the tongue. They are seen one upon each side of the frænum, where they form a ridge beneath the mucous membrane. Each of them accompanies the corresponding hypoglossal nerve, between the genio-hyoglossus and hyoglossus muscles, and terminates either in the common trunk of the lingual and facial veins, or directly in the facial vein.

The ranine veins communicate upon the sides of the tongue with a very large plexus, the vessels composing which are sometimes provided with valves, so that it is impossible to inject it in a direction from the heart towards the extremities of the veins, which, in other cases, may be done with the greatest facility.

Lastly, the *lingual veins*, properly so called, are extremely small; they are two in number, and accompany the lingual artery throughout the whole of its course. Not unfrequently the veins of the tongue terminate directly in the internal jugular; I have seen them open into the anterior jugular.

The Pharyngeal Vein and Pharyngeal Plexus.

The pharyngeal plexus. In making the section already described for examining the pharynx, we observe round the back of that organ a considerable venous plexus, which forms loops or rings embracing the pharynx; several *meningeal branches*, and some, derived from the *vidian* and *spheno-palatine veins*, open into this plexus; from which a variable number of *pharyngeal branches* arise, and terminate by a common trunk, or by several distinct branches, in the lingual vein, sometimes in the facial or the inferior thyroid, and frequently in the internal jugular.

Besides this plexus, which may be called the *superficial* pharyngeal plexus, an extremely dense network is found beneath the mucous membrane, from which branches proceed to join with those that arise from the superficial plexus just described.

The Superior and the Middle Thyroid Veins.

The *superior thyroid*, or *thyro-laryngeal vein*, commences upon the thyroid gland by branches corresponding to the thyroid arteries, and upon the larynx by branches corresponding to the ramifications of the superior laryngeal artery. The thyroid and laryngeal branches unite and end in the internal jugular vein, opposite the upper part of the larynx; they perhaps end more frequently in the common trunk of the facial and lingual veins. It is not uncommon to find the superior laryngeal branch terminating directly either in one or the other of these veins, or in the anterior jugular.

The *middle thyroid vein* arises from the lower part of the lateral lobe of the

thyroid gland, and is joined by some branches from the larynx and the trachea. By their union they form a trunk, which ends in the lower part of the internal jugular vein. The constant existence of this vein explains in some degree a rather frequent variety in the arteries of the thyroid gland, viz. the existence of a middle thyroid artery given off by the common carotid. Not unfrequently there are two middle thyroid veins on each side. These, as well as all the other thyroid veins, are much enlarged in goître.

The Veins of the Diploe.

To complete the description of the veins of the head, it only remains for me to notice the *diploic veins*, or the proper veins of the bones of the cranium. They were first described by M. Dupuytren in his inaugural thesis, under the name of *venous canals of the bones:* they were afterwards figured by M. Chaussier (*Traité de l'Encéphale*), and, together with their principal varieties, they have lately been represented with uncommon accuracy by M. Breschet, in his admirable work upon the veins.

In the substance of the cranial bones there are found ramified venous canals, which are occupied by veins having only their internal membrane, the bony canals themselves serving for an external coat. These venous canals are not exclusively confined to the bones of the cranium: they exist in all spongy bones, and even in compact bones; but whilst the canals are found in the entire substance of spongy bones, in the compact part of the long bones they are situated near the medullary canal.

The venous canals of the bones of the cranium vary much in their size, and in the extent to which they are distributed: they are independent of each other, as long as the cranial bones remain distinct and separable; but they almost always communicate when, in the progress of age, those bones become united together. They get larger and larger as life advances, and their size is indirectly proportioned to the number of their ramifications: they sometimes present ampullæ or dilatations, and at other times are suddenly interrupted, and terminate in culs-de-sac, reappearing again further on, or ceasing altogether: these peculiarities depend upon the venous canal opening at different points into the middle meningeal veins. Moreover, these venous canals communicate by a number of orifices of different sizes, either in the interior of the cranium with the meningeal veins, and with the sinuses of the dura mater, or on the exterior with the veins which lie in contact with the bones of the skull.

In some heads of old subjects, these canals are found blended with the furrows for the branches of the meningeal arteries; those furrows themselves present some large foramina, which open into the cranium in various places.

In new-born infants there are no venous canals properly so called; but the whole substance of the bones is traversed by a venous network, which may be seen when its constituent veins are naturally injected with blood, or when they have been filled with mercury, by which as delicate a network of vessels can be shown in the diploe as in injections of the soft parts. At this period all the cells of the bones are filled with venous blood.

On the roof of the cranium the canals of the diploe are divided into the *frontal*, *temporal*, *parietal*, and *occipital*.

The *frontal diploic canals* are two in number, one on the right, the other on the left side: they commence by numerous ramifications upon the upper part of the frontal bones, increase in size as they approach the lower part of the roof of the skull, communicate with each other by transverse branches, and also with the periosteal or the meningeal veins, open externally by vascular foramina, and then enter the supra-orbital and frontal veins.

The *temporo-parietal diploic canals* are divided into anterior and posterior: they correspond to the furrows which contain the ramifications of the meningeal artery, and open into those furrows by a great number of foramina, which

become very distinct in advanced life: they also communicate with the deep temporal veins on the exterior of the skull.

The *occipital diploic canals*, two in number, a right and a left, communicate with each other by a great number of branches, and open below into the occipital veins.

Summary of the Distribution of the Veins of the Head.

Circulation in the brain. Corresponding to two of the arterial trunks, the common carotids, which convey blood to the head and neck, there are six veins, to return it back to the heart from the same parts, viz. the two internal, the two external, and the two anterior jugulars. This arrangement tends to prevent interruption of the venous circulation in the head, which, from so many causes, is liable to be disturbed. The external and anterior jugular veins belong to the subcutaneous venous system, and may be regarded as supplementary veins which have no corresponding arteries, and which would be sufficient of themselves to carry on the venous circulation; and as the veins of the right and left sides communicate very freely with each other, it follows that one of them would suffice to return the blood from the head. It will be seen hereafter, when describing the veins of the spine, that the obliteration of all the six jugular veins would not of necessity be followed by interruption of the venous circulation in the cranium. Lastly, it is important to observe, that the external and anterior jugulars open into the subclavian vein, whilst the internal jugular joins the inner end of the subclavian, to form the brachio-cephalic vein.

We have seen that the lower part of the internal jugular vein represents the common carotid, and the upper part of it the internal carotid; and that the external carotid is represented by all the veins of the face and neck, which open into the internal jugular either by a common trunk, or by several distinct branches.

The cerebral venous system is remarkable for the extreme thinness of the parietes of the veins upon the brain, and for the existence of the sinuses, which take the place of the venous trunks, and differ so much in their distribution from the arteries. The cerebral veins are divided into the *ventricular veins*, which go to form the venæ Galeni and the *superficial veins of the brain.* All of them run towards the sinuses, in which they terminate in succession like the barbs of a feather upon the common shaft, but do not acquire a great size. From the absence of valves at their orifices into the sinuses, the blood may regurgitate into them. The presence of the spongy areolar tissue at the orifices of these veins, together with their oblique course through the walls of the sinus, must diminish this regurgitation: the communication of the cerebral veins with each other, and the continuity of the several sinuses, explain the varied means contrived for carrying on the cerebral circulation, which can only be interrupted by obliteration of the lateral sinuses.

Lastly, the position of the principal sinuses opposite the fissures between the great divisions of the encephalon, and the resisting nature of the walls of the sinuses themselves, prevent the fatal effects which might otherwise ensue from compression produced by obstruction of the venous circulation.

Circulation in the parietes of the cranium. In the parietes of the cranium we find, the veins of the dura mater, the veins of the diploe, the periosteal veins, and the veins of the hairy scalp. The numerous communications existing between these four systems of veins, and the direct communications established between the sinuses of the dura mater and the veins on the exterior of the skull, are worthy of particular attention. I would observe that the principal veins of the scalp, like the arteries of the same part, are situated between the skin and the epicranial aponeurosis. I have ascertained the existence of free and frequent anastomoses amongst these veins. As at the back of the cranium there is a very free communication between the occipital vein and the lateral sinus by means of a large vein, so, also, along the superior

longitudinal groove, and opposite the sutures upon the base of the skull (through most of the foramina found in that situation), an uninterrupted communication is established between the veins within and those outside the cranium.

Venous circulation of the face. All the veins of the face and of the parietes of the cranium end in two principal trunks, the facial and the temporal. The facial vein corresponds to a part of the internal maxillary artery, to a part of the ophthalmic artery, and to the facial artery properly so called. One of the most remarkable circumstances connected with the distribution of the facial vein is, the communication between it and the cavernous sinus, established at the inner angle of the orbit by means of the ophthalmic vein, so that the veins on the inside and on the outside of the cranium are most intimately connected.*

The temporal vein represents the temporal artery, a part of the internal maxillary artery, and the upper part of the external carotid, and returns the blood from the entire side of the head.

With regard to the veins of the tongue, we should remark the existence of two submucous veins, corresponding to the subcutaneous veins in the limbs, and intended to return the blood, instead of the deep veins of the tongue, during the contractions of that organ.

The size of the superior middle thyroid veins, their number, which exceeds that of the arteries, and their free anastomoses with the inferior thyroid veins, render them an important medium of circulation when the passage of the blood from the head is obstructed, and at the same time a *diverticulum* in great impediments to the circulation.

The irregularity which exists in the relative size of the internal, external, and anterior jugular veins, and also in the distribution of the veins of the head between these three trunks, proves that, in the venous as well as in the arterial system, the origin or termination of the vessels is of little importance, and that after the venous system of any part is once formed, it matters but little with which of the great vascular trunks it is connected.

Lastly, the free communications which exist between all the preceding veins afford sufficient evidence that but little interest need be attached to their termination in one or another of the principal venous trunks.

The Deep Veins of the Upper Extremity.

The *veins of the upper extremity* are divided into the deep and the superficial or subcutaneous.

The Palmar, Radial, Ulnar, Brachial, and Axillary Veins.

The *deep veins of the upper extremity* exactly follow the course of the arteries, form their venæ comites, and take the same names: there are almost always two to each artery. The large venous trunks alone form exceptions to this rule. Thus, there are two *superficial* and two *deep palmar* veins; two *deep radial* and two *deep ulnar* veins; we also find two *brachial* veins; but there is only one *axillary* and one *subclavian* vein. All these venæ comites receive branches formed by the union of still smaller ones, which are themselves the venæ comites of the ramifications of the arteries, there being two veins with each small artery. The subclavian vein, however, is an exception to this, for it does not receive all the veins which correspond to the branches of the sub-

* The study of these anastomoses ought to lead us again to have recourse to those local venesections which have fallen into disuse since the discovery of the circulation; and it will enable us to determine, on anatomical grounds, the proper places at which they should be performed. Thus it appears to me, that we might advantageously introduce into practice bleeding from the angular vein in diseases of the eye; from over the mastoid region, and the point which corresponds to the junction of the longitudinal with the lambdoidal suture, in cerebral affections; and bleeding from the ranine vein in diseases of the pharynx.

clavian artery; whilst, on the other hand, it receives other veins that are totally unconnected with the distribution of that artery. I ought to allude in this place to a mode of termination of the collateral veins, which is frequently observed, especially in the brachial vein. The circumflex veins for example, instead of entering the brachial vein directly, terminate in a collateral branch, which runs parallel to the brachial vein, like a canal running alongside a river, and communicates with that vein above and below. Several large veins have these collateral canals, which establish a communication between different points of their length. Thus, I have seen a venous trunk proceed from the external jugular, descend through the brachial plexus of nerves, and enter the lower part of the axillary vein.

The deep veins, moreover, communicate freely and frequently with the superficial veins. They are, also, provided with valves, like the superficial veins, and, it appears, even with a greater number: an injection thrown from the heart towards the extremities will not enter more readily into one than into the other set. We always find two valves at the mouth of a small vein where it opens into the larger trunk; and it is a remarkable fact, that, while the valves situated in the course of the veins are sometimes passed by the injection, those which are placed at the mouths of the small veins are scarcely ever overcome.

The Subclavian Vein.

The term *subclavian* is generally given to all that portion of the brachial venous trunk which extends from the vena cava superior to the scaleni muscles: but this vein may be described more naturally, as being limited internally by the brachio-cephalic vein, or rather by the junction of the internal jugular vein with the venous trunk of the upper extremity, and externally by the clavicle, or rather by the costo-coracoid or subclavian aponeurosis. If the subclavian veins be thus defined, they will be of equal length on both sides; and the left vein, and even the right vein also, will be shorter than the corresponding artery.

The *direction* of the subclavian veins differs much from that of the arteries; we have seen that the subclavian arteries describe a curve over the apex of the lung, with its concavity turned downwards; the subclavian veins, on the contrary, proceed directly outwards as far as the first rib, over which they bend, so that they resemble the cord of the arc described by the subclavian artery. We have seen, also, that the inferior thyroid vein, the internal mammary, the vertebral, the supra-scapular, the posterior scapular, the deep cervical, and the left superior intercostal veins, enter not into the subclavian, but either into the superior vena cava or into the brachio-cephalic vein. The right superior intercostal vein, when it exists, that is to say, when the branches which should form it do not terminate separately in the vena azygos, is the only one of the veins corresponding to the branches of the subclavian artery which opens into the subclavian vein.

The external jugular, the anterior jugular, and a small branch from the cephalic vein of the arm, also terminate in the subclavian vein. It would therefore, in some respects, be proper to describe the external and anterior jugulars in connection with the subclavian vein, instead of with the internal jugular. I would remark, that the external and anterior jugulars frequently terminate, not in the subclavian vein, but at the point where it ends in the brachio-cephalic vein, in front of the internal jugular.

Relations. In front of the subclavian vein is situated the clavicle, which is separated from the vein only by the subclavian muscle, so that this vessel may be wounded in fractures of the clavicle: a very dense fibrous sheath binds it down to the subclavius muscle; and it perforates the costo-coracoid or subclavian aponeurosis, which adheres to it, and keeps it open when cut across; *behind* the vein is the subclavian artery, from which it is separated, towards the inner

part, by the scalenus anticus; *below*, it is in relation with the pleura and with the first rib, on which there is a corresponding but slight depression; *above*, it is covered by the cervical fascia, which separates it from the skin: a considerable swelling is often seen in this region, when the venous circulation is obstructed.

The Superficial or Subcutaneous Veins of the Upper Extremity.

The *subcutaneous veins of the upper extremity* belong essentially to the skin and to the subjacent adipose tissue, since all the branches from the muscles enter the deep veins. The superficial are larger than the deep veins, with which they communicate freely at a great number of points; and it may be remarked, that the size of the one set of vessels is always inversely proportioned to that of the other set. We proceed to describe them in succession in the hand, the forearm, and the arm.

The Superficial Veins of the Hand.

All the largest veins of the hand are situated upon its dorsal aspect; and it is worthy of notice, that the largest arteries, on the contrary, occupy the palm of the hand. If the superficial veins had existed on the palmar aspect, the venous circulation would have been impeded whenever the hand was used in prehension. Entering into the large subcutaneous network of veins situated upon the back of the hand are several branches, which constitute the *superficial, external, and internal collateral* veins of each finger; they occupy the outer and inner borders of the dorsal surface of the fingers, and communicate frequently on the dorsal surface of each phalanx and around the phalangeal articulations, but not upon the articulations themselves.

Opposite the lower part of each interosseous space, these collateral veins unite at an acute angle, just as the digital arteries bifurcate at the same point. All the superficial digital veins ascend vertically between the metacarpo-phalangeal articulations, which they seem to avoid, and then enter into the convexity of a very irregular venous arch, which is formed by a series of loops, at each of the junctions of which one of the digital veins is seen to terminate.

From the concavity of this irregular arch, which is turned upwards, are given off a greater or less number of ascending branches, which are sometimes formed directly by the junction of the digital veins, without the intervention of an arch. Among these branches, we should especially notice the external branch, which is situated nearest to the first metacarpal bone, and is called the *cephalic vein of the thumb*; also the innermost branch, which corresponds to the fifth metacarpal bone, and, for some reason, not very well known, has been named the *vena salvatella*.

The Superficial Veins of the Forearm.

The superficial veins are much more numerous on the anterior than on the posterior aspect of the forearm. We find there the radial vein or veins, the ulnar vein, and the median vein.

The *superficial radial vein* (*r*, in the representation of the superficial nerves of the arm) is the continuation of the cephalic vein of the thumb, it is situated along the outer side of the carpus and of the radius, and it soon unites with some branches from the vena salvatella, or with the salvatella itself. The superficial radial vein often divides into several branches, which are joined by others from the venous arch at the back of the hand. There are sometimes two superficial radial veins. The vein or veins having reached the middle of the forearm, turn forwards upon the outer border of the radius, and then continue to ascend vertically along the outer side of the anterior surface of the forearm, up to the bend of the elbow.

The *ulnar vein* (*u*) commences partly from the vena salvatella, and another

vein on the dorsal region of the forearm, and partly from some branches which arise from the lower part of the back of the forearm, and even from some small veins proceeding from the thenar and hypothenar eminences.

The branches which arise from the vena salvatella and the back of the wrist pass forwards; the other branches run backwards; the common trunk or trunks resulting from their union are directed at first vertically upwards, parallel with the superficial radial vein, then somewhat obliquely forwards, to anastomose with the median basilic vein, above the bend of the elbow. When there is a second or *posterior ulnar vein*, it ends in the basilic higher up, or else it anastomoses with the anterior ulnar vein.

Between the anterior radial and ulnar veins we find the *common median* or *median vein* (*m*), formed by the anterior veins of the carpus and forearm. There may be more than one median vein, and it is not unfrequently wanting, in which case its place is supplied by a venous network, the branches from which enter separately into the radial and ulnar veins. In some cases its place is supplied by an additional radial vein, and at other times by the deep veins.

The Superficial Veins at the Elbow.

At the elbow all the veins are on the anterior aspect. The most common arrangement is the following: on the outer side we find the upper portion of the radial vein or veins; on the inner side, the upper portion of the ulnar vein or veins, which pass in front of the internal condyle of the humerus; between the radial and ulnar veins is the median, which divides into two branches,— one external (*a*), which unites with the radial to form the cephalic vein (*c*), and is called the *median cephalic;* the other internal (*e*), generally smaller, but more superficial than the preceding, which unites with the ulnar to form the basilic vein (*b*), and is called the *median basilic.*

Several varieties are observed in the arrangement of the veins of the elbow; sometimes the common median vein is wanting; but then its cephalic and basilic branches are given off by the radial, and the cephalic vein is almost always very small. In other cases we only find two veins at the bend of the elbow, viz. the radial and the ulnar, which are directly continuous with the cephalic and basilic. I once saw the common median vein replaced by the anterior radial, and by a branch from one of the deep ulnar veins.

The Superficial Veins in the Arm.

In the arm there are only two superficial veins, an external, named the *cephalic* vein, and an internal or *basilic.*

The *cephalic vein* (*c*) is formed by the junction of the radial with the median cephalic vein, which junction may occur at very different heights. It ascends vertically along the outer border of the biceps; then, running a little inwards, it gains the furrow between the deltoid and pectoralis major, passes over the summit of the coracoid process, above or in front of which it curves backwards, so as to enter the axillary vein immediately below the clavicle. From this curve the cephalic vein gives off a branch, which passes in front of the clavicle, crosses at right angles over the middle of that bone, and enters the subclavian vein. Not unfrequently the cephalic vein is replaced by a very small branch.

The internal vein of the arm, which is called the *basilic vein* (*b*), is generally larger than the cephalic. It is formed by the junction of the ulnar with the median basilic vein, passes at first obliquely backwards, and then vertically upwards, in front of the internal intermuscular septum, and enters either the brachial or the axillary vein.

General Remarks upon the Superficial Veins of the Upper Extremity.

From the preceding description it follows, that the cephalic vein forms the continuation of the radial, which is itself the continuation of the cephalic vein of the thumb, and that the basilic is a prolongation of the ulnar, which is a continuation of the vena salvatella. The median vein, placed as it is between the radial and ulnar veins, bifurcates so as to terminate equally in the two latter veins, and establishes a free anastomosis between them.

The anastomoses of the several subcutaneous veins together are very numerous, and enable them mutually to supply the place of each other. The anastomoses between the subcutaneous and deep veins are not less numerous. Thus, the superficial collateral veins of the fingers communicate with the deep collateral veins: communications exist between the superficial and deep veins of the carpus: very large communications exist between the two sets of vessels at the bend of the elbow, so that, in fact, they are continuous with each other; thus, the superficial radial vein is sometimes continuous with one of the deep radials, and the median, as it divides into the median basilic and median cephalic, occasionally sends a very large branch to the brachial. In one case, where the median vein was wanting, I found that the ulnar, the deep interosseous, and the deep radial veins, formed a plexus, which gave off two branches, an external to the cephalic, and an internal, which formed the deep brachial vein. The superficial ulnar veins often communicate freely with the deep ulnar, beneath the muscles attached to the internal condyle.

Along the arm, the basilic vein communicates with one of the brachial veins by several transverse branches. Not unfrequently the basilic vein communicates with the brachial by a very delicate branch, which forms a lateral canal.

Valves. The valves are more numerous in the deep than in the superficial veins; they increase in number as we approach the upper part of the arm, and are much more numerous in the basilic than in the cephalic vein. There are three in that part of the cephalic which corresponds to the furrow between the deltoid and the pectoralis major. There is one at the opening of the cephalic into the axillary; another at the opening of the basilic into the brachial: all the small veins which enter the cephalic and basilic, as well as those which terminate in the deep veins, are also provided at their openings with valves, which prevent the regurgitation of the blood during life, and the passage of an injection from the heart towards the extremities.

General relations. The subcutaneous veins are separated from the skin by the *superficial fascia*, and by the layer of fat above it. The median basilic is the only exception, for it is in contact with the skin, at least in the majority of subjects.

The *subcutaneous veins* must be carefully distinguished from the *cutaneous veins*, properly so called, which are in contact with the true skin, or even ramify in its substance, and which are sometimes of considerable size, especially in the neighbourhood of certain tumours.

From the relation of the median basilic vein with the brachial artery, over which it crosses at a very acute angle, and from which it is separated only by the fibrous expansion from the tendon of the biceps, it follows, that in emaciated persons the vein is almost in contact with the artery; so that, in bleeding from the median basilic, if the vein be perforated quite through, the artery may be wounded. The practical rules to be derived from this anatomical fact are, in the first place, to avoid bleeding in the median basilic as much as possible, and whenever it must be chosen, to open it either below or above the point where it crosses over the artery.

In the description of the lymphatics and nerves of the arm, I shall point out their relations with the superficial veins. I may now state, however, that the

musculo-cutaneous nerve passes behind the median cephalic vein, and that the internal cutaneous divides into several branches, some of which pass in front, and others behind the median basilic vein.

THE INFERIOR OR ASCENDING VENA CAVA AND ITS BRANCHES.

The Inferior Vena Cava — the lumbar or vertebro-lumbar veins — the renal — the middle suprarenal — the spermatic and ovarian — the inferior phrenic. — The Portal System of Veins — the branches of origin of the vena portæ — the vena portæ — the hepatic veins. — The Common Iliacs — the internal iliac — the hæmorrhoidal veins and plexuses — the pelvic veins and plexuses in the male and in the female.—The Deep Veins of the lower extremity — the plantar, posterior tibial, peroneal, dorsal, anterior tibial, and popliteal — the femoral — the external iliac. — The Superficial Veins of the lower extremity — the internal saphenous — the external saphenous.

The *vena cava inferior* or *ascendens*, or the *abdominal vena cava* (*l*, *fig.* 222.), is the large venous trunk which returns the blood from all the parts below the diaphragm to the heart.

It is formed below by the junction of the two common iliac veins (*n n*), opposite the intervertebral substance between the fourth and fifth lumbar vertebræ; it passes vertically upwards, and having reached the lower surface of the liver, inclines a little towards the right side, to gain the groove formed for it in the posterior border of that organ. At the upper end of that groove the vena cava inferior perforates the tendinous opening in the diaphragm, and also the fibrous layer of the pericardium, which is, as it were, blended with the cordiform tendon at this point; the vein then curves suddenly to the left, and opens (*r*, *fig.* 192.) horizontally into the posterior inferior part of the right auricle.

It is larger than the vena cava superior, but is not of uniform caliber throughout; for example, it increases in size in a marked degree immediately above the renal veins. The vena cava inferior presents also a second still larger dilatation opposite the liver, where it is joined by the hepatic veins; in comparison with its diameter at that point, the vena cava inferior appears to be slightly contracted as it passes through the diaphragm.

Relations. The inferior cava is in contact with the anterior surface of the vertebral column, and runs throughout the whole of its extent along the right side of the aorta; it inclines somewhat obliquely to the right as it is about to pass into the groove on the liver. In front it is covered by the peritoneum, the third portion of the duodenum, the pancreas, the vena portæ, which crosses it at a very acute angle, and at its upper part by the liver, which forms a semi-canal, or a complete canal for it.

It adheres closely to the margins of the tendinous opening in the diaphragm, and to the fibrous layer of the pericardium, as if its outer coat were blended with those structures.

The serous layer of the pericardium covers the vein, but the fibrous layer does not form a sheath for it. The relations of the inferior cava with the liver account for the erroneous notion of some old anatomists, that this organ was the centre from which all the veins of the body proceeded.

There is no valve in the inferior cava; but at its termination we find the Eustachian valve, which has been already described with the heart.

Branches of origin. We have stated that the junction of the common iliac veins constitutes the origin of the inferior cava. It is very rare to find these veins uniting above the intervertebral disc between the fourth and fifth lumbar vertebræ; but in some few cases the junction has been observed to take place opposite the renal veins.

Collateral branches. The vena cava inferior receives all the veins corresponding to the branches of the abdominal aorta, excepting the veins from the

alimentary canal and its appendages, of which it only receives those from the liver, viz. the hepatic veins. All the abdominal veins which do not open directly into the inferior cava unite to form a large venous trunk, called the *vena portæ*. Thus the vena cava inferior receives the renal, the spermatic or ovarian, the lumbar, the suprarenal, and the inferior phrenic veins; whilst the superior and inferior mesenteric, the splenic, the pancreatic, and the gastric veins open into the vena portæ. It may still be said, however, that the vena cava inferior receives all the abdominal veins; for, in fact, the veins of the portal system terminate in the vena cava through the medium of the hepatic veins. The portal system is therefore an appendage to the inferior cava. For this reason, and also for the sake of economising subjects, I shall not describe the vena portæ and its branches until I have noticed the collateral veins of the vena cava inferior.

The Lumbar, or Vertebro-lumbar Veins.

The *vertebro-lumbar veins* are three or four on each side, and correspond to the arteries of the same name; they have two branches of origin — an *external* or *abdominal* branch, which represents the intercostal veins, and a *posterior* or *dorso-spinal* branch, which is itself formed by the union of two other branches; one *muscular* or *cutaneous*, which commences in the muscles and integuments, and the other a proper spinal branch, which forms part of the rachidian venous system, to be hereafter described.

By the junction of these two branches a lumbar vein is formed, which runs forwards and inwards in the groove on the body of the corresponding lumbar vertebra, and enters the vena cava at a right angle. The left lumbar veins are longer than the right, in consequence of the vena cava being situated towards the right side of the vertebral column: they pass under the aorta.

The Renal Veins.

The renal veins are remarkable for their size, and occasion a great increase in the diameter of the inferior cava, above the point where they open into it; they are of unequal size on the two sides, and are unequal in length, on account of the vena cava being placed towards the right side of the vertebral column, and therefore nearer the right than the left kidney: they also run more obliquely on the right side, on account of the right kidney being generally situated lower down than the left.

These veins commence in the substance of the kidney by a number of minute divisions, which unite into small, and then into larger branches, gain the surface of the organ, and are collected into a single trunk, either in the hilus, or at some distance from it. The trunk of each renal vein is always placed in front of the corresponding artery. The left renal vein passes in front of the aorta. We sometimes find one division of the left renal vein in front of the aorta, and another behind it.

Plurality of the renal vein appears to me less common than an excess in the number of the arteries.

The renal veins receive the *inferior suprarenal* and several veins from the surrounding adipose tissue. The left renal vein is almost always joined by the *spermatic* or *ovarian vein* of that side.

In some cases we find several communicating branches between the left renal vein and the superior mesenteric, which is one of the branches of the portal system.

The Middle Suprarenal Veins.

The *middle suprarenal* or *capsular veins*, which are often numerous and very large, are found on the surface of the suprarenal capsules, whilst the

arteries enter into their substance from every point. The venous trunks run in the grooves seen upon the surface of the organ. The left middle suprarenal vein almost always enters the renal vein of the same side; the right vein generally opens into the vena cava inferior.

The Spermatic or Ovarian Veins.

The *spermatic veins* commence in the interior of the testicle, where they form a great number of those filaments which traverse the proper substance of the gland: they all terminate in branches, which are applied to the inner surface of the tunica albuginea, and are bound down to it by a thin layer of fibrous tissue, a disposition somewhat resembling that of the sinuses of the dura mater. The spermatic veins perforate the tunica albuginea on the inner side of the epididymis, not opposite that body. They are soon joined by the veins of the *epididymis*, so as to form a plexus, which communicates with the dorsal veins of the penis, and with the external and internal pudic veins. The spermatic veins soon unite into five or six trunks, which pass upwards in front of the vas deferens, and together with that canal and the spermatic artery enter into the formation of the spermatic cord. These veins are tortuous; they divide, and anastomose so as to form the *spermatic venous plexus*, which is often the seat of varicose dilatations. The veins ascend through the inguinal ring and canal, and having reached the interior of the pelvis, they leave the vas deferens, accompany the corresponding spermatic artery along the psoas muscle, and terminate either in the renal vein, or in the inferior vena cava of their own side.

In some cases the right spermatic vein opens both into the renal vein and the inferior cava. When there are two veins on one side, they communicate with each other by a great number of transverse branches, and before terminating unite into a single trunk.

The name *plexus pampiniformis* is given to a plexus generally formed by the spermatic veins before their termination: this plexus is more frequently found on the left than on the right side, according to the observations of Meckel.

The spermatic veins sometimes communicate with some branches of the portal system.

The left spermatic vein passes under the sigmoid flexure of the colon, which may perhaps account for the greater frequency of varicocele on the left side.

The *ovarian veins* accompany the arteries of the same name: they commence by several sets of branches, viz. *uterine* branches, which communicate very freely with the uterine sinuses; *ovarian* branches, properly so called; branches from the *round ligaments*; and, lastly, some from the *Fallopian tubes.* All these unite within the substance of the broad ligaments, and pass vertically upwards without being at all tortuous: in some cases they form a *plexus pampiniformis.*

The ovarian veins, like the uterine veins, become much enlarged during pregnancy.

The Inferior Phrenic Veins.

These exactly follow the course of the inferior phrenic arteries, to each of which there are two veins.

The *hepatic veins* do not in any way correspond to the artery of that name; they form a separate system, or, rather, they are connected with the portal venous system, of which they may be regarded as an appendage.

The Portal System of Veins.

The system of the *vena portæ* (*vena portarum*), or the portal system, constitutes a special venous apparatus, appended to the general venous system, and re-

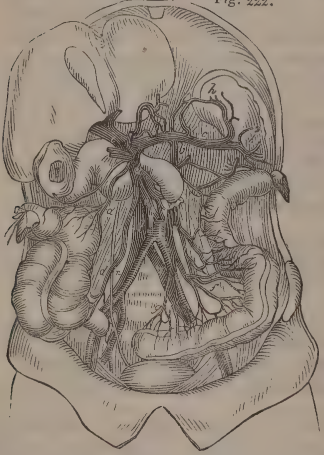
presenting by itself a complete circulatory tree, having its roots, trunk, and branches. The first, or venous portion of this system of veins is arranged like the veins of the other parts of the body, and has its roots of origin in the spleen and pancreas, and in the sub-diaphragmatic portion of the alimentary canal; whilst the second, or arterial portion, sends its branches, like those of an artery, into the interior of the liver.

The hepatic veins, which perform the functions of ordinary veins in reference to the second or arterial portion of the vena portæ, connect the system of the vena portæ with the general venous system.

The Branches of Origin of the Vena Portæ.

The branches of origin of the vena portæ (*i*, *fig.* 222.) consist of all the veins which return the blood from the sub-diaphragmatic portion of the alimentary canal, and also from the spleen and pancreas. They correspond to the branches of the cœliac axis, with the exception of the hepatic artery; they unite into three trunks, the *great mesenteric* (*a*), *small mesenteric* (*b*), and *splenic* (*c*) *veins.*

Fig. 222.



These veins are arranged like venæ comites to the corresponding arteries.

The great and small mesenteric veins. The *intestinal* or *mesenteric veins* commence just as the arteries terminate, by two layers of vessels, viz. a subserous layer, the vessels of which ramify beneath the peritoneum, and a deep layer, formed by the vessels of the coats of the intestinal canal. These small vessels unite into anastomotic meshes, which always lie subjacent to the arterial network, and which terminate in larger branches, and thus constitute a series of veins corresponding to the arteries of the intestine. The right *colic veins* (*d d*) and the *veins of the small intestine* (shown cut short at *e*) terminate, the one in the right and the other in the left side of the *superior mesenteric* or *great mesaraic vein* (*a*): this vein, in the early periods of intra-uterine life, receives the *omphalo-mesenteric vein*, a branch which corresponds to the omphalo-mesenteric artery, and commences upon the vesicula umbilicalis; the artery and the vein disappear about the third month of utero-gestation, but the vesicle remains for a longer period. On the other hand, the *left colic veins* (*f*) enter the *inferior mesenteric* or *small mesaraic vein* (*b*): this vessel forms the continuation of the *superior hæmorrhoidal veins* (*g*), which communicate very freely with the middle and inferior hæmorrhoidal branches of the internal iliac vein.

The *splenic vein* (*c*), which is proportionally larger than the artery, arises in the cells of the spleen by a great number of roots, which gradually unite in the hilus of that organ, and form the same number of branches as there are arteries, each coming from a distinct compartment of the organ. All these branches soon unite into a single trunk, which passes across to the right side behind the pancreas, and therefore behind the splenic artery, which it accompanies without being tortuous: it is one of the branches immediately concerned in forming the trunk of the vena portæ. During its course, the splenic vein receives the venous *vasa brevia* (*h h*) from the stomach.

The inferior mesenteric vein opens into the splenic; so that there are only

two venous trunks, the union of which constitutes the vena portæ, viz. the splenic and the great or superior mesenteric.

The Vena Portæ.

The trunk of the *vena portæ* (*i*) is formed by the union of the splenic and superior mesenteric veins at an acute angle, behind the right extremity of the pancreas, in front of the vertebral column, and to the left of the vena cava inferior. The vena portæ is larger than either of its two branches of origin, but is smaller than the two taken together. It passes obliquely upwards and to the right side; and, after running for about four inches, reaches the left extremity of the transverse fissure of the liver, where it terminates by bifurcating. The following are its relations during its course: anteriorly it is covered by the head of the pancreas, the second portion of the duodenum, the hepatic artery, the biliary ducts, and the lymphatics of the liver, and also by some branches from the hepatic plexus of nerves; posteriorly it is covered by that portion of peritoneum which dips behind the vessels of the liver into the foramen of Winslow, to line the sac of the great omentum. By this foramen it is separated from the inferior vena cava, the direction of which it crosses at a very acute angle.

The two branches into which the vena portæ divides in the transverse fissure of the liver separate so widely from each other, that they seem to form a trunk, at right angles to which the vena portæ itself is attached. Some anatomists apply the term *sinus of the vena portæ* to that portion of the vein which is situated in the transverse fissure: that part of the vein which adheres to the liver is more commonly called the *hepatic* portion of the vena portæ, to distinguish it from the free and floating part, which is named the abdominal portion.

The two divisions of the vena portæ pass horizontally each towards the corresponding lobe of the liver: they soon divide and subdivide into diverging branches, which supply all the granules or lobules of the liver. The branches of the vena portæ are accompanied by the ramifications of the hepatic artery and biliary ducts. The capsule of Glisson, or the fibrous coat of the liver, is reflected upon them, and forms a common sheath for them. (See Liver.)

Before birth, the hepatic portion (*p*, *fig.* 164.) of the vena portæ receives, besides the abdominal portion of the same vein, the *umbilical vein* (*u*), which is obliterated soon after birth. Nevertheless, I once found it perfectly permeable in an adult.*

Before birth the *ductus venosus* (*d*) extends from the hepatic portion of the portal vein to the vena cava inferior, between which and the vena portæ it establishes a direct communication. This hepatic portion might therefore be named the confluence of the veins of the liver.

The Hepatic Veins.

The capillary radicles of the *hepatic* or *supra-hepatic veins* commence in the capillary divisions of the vena portæ, and, gradually uniting into larger and larger branches, converge towards the posterior border of the liver, or rather towards the fissure for the vena cava inferior, at which point they terminate by an indefinite number of small branches, named the *small hepatic veins*, which open all along the fissure; and also by two principal trunks, the *great hepatic veins*, which end in the vena cava immediately before it passes into the opening in the diaphragm. One of these great hepatic veins comes from the right lobe, and the other from the left lobe of the liver.

The vein of the left side often receives a great number of branches from the right lobe of the liver, and is larger than the vein of the right side.

The vena cava inferior is always dilated into a large ampulla opposite the openings of the hepatic veins.

* Anat. Pathol. livraison 17.

It follows, from the previous description, that, in the liver, the branches of the hepatic veins and those of the vena portæ run directly across each other, since the latter diverge from the centre of the organ towards its right and left extremities, while the former converge from the anterior towards the posterior border.

Moreover, the branches of the hepatic veins are unaccompanied by other vessels, and are in direct contact with the tissue of the liver; whilst those of the vena portæ are separated from it by the capsule of Glisson, and are accompanied by the ramifications of the artery, the nerves, and the hepatic ducts.

I shall further remark, that, although the hepatic veins gradually unite like other veins into branches, which decrease in number, but increase in size, they most of them receive besides, during their course, a multitude of capillary vessels, the interlobular hepatic veins, from the neighbouring lobules; so that their internal surface is perforated with innumerable foramina.

The cribriform structure of their internal surface is therefore a peculiar characteristic of all the hepatic veins [except the very large ones], and enables us always to distinguish them from the branches of the vena portæ.

Lastly, the capillary communication between the extremities of the vena portæ and hepatic veins is extremely free, as may be shown even by very coarse injections.

All the veins of the portal system are without valves*, and they can therefore be injected with the greatest ease from the trunks towards the extremities. An injection thrown in towards the intestine penetrates very readily into the interior of the alimentary canal, so that the minute branches of the vena portæ appear to open at the apex of each villus. This can be made evident by throwing mercury into the vena portæ, and then forcing it on by an ordinary injection; drops of the mercury will then be seen in the open mouth of each villus.†

The system of the vena portæ is not so completely isolated from the general venous system as is commonly stated. It always communicates with branches of the internal iliac veins by means of the middle hæmorrhoidal veins, and communicating branches with the renal veins have also been noticed; and hence injections of the vena cava inferior always enter in a greater or less degree into the veins of the portal system.

The common Iliac Veins.

The *common iliac veins* (*n n*, *fig.* 222.) correspond exactly to the arteries of the same name; they commence opposite the sacro-vertebral articulation by the junction of the internal and external iliac veins, and terminate by uniting at an acute angle to form the vena cava inferior or ascendens, the point of union being opposite the articulation of the fourth and fifth lumbar vertebræ, to the right side of, and a little below, the bifurcation of the aorta.

The common iliac veins have the same relation to the lower extremities that the brachio-cephalic veins bear to the upper; and as the right brachio-cephalic vein is shorter and more vertical than the left, so also is the right common iliac vein shorter and more vertical than the left.

The relations of the common iliac veins with the corresponding arteries is remarkable, inasmuch as they are placed between these vessels and the vertebral column. The *right* common iliac vein is situated to the outer side of and behind the corresponding artery, and is parallel to it; whilst the *left* common iliac is situated on the inner side, and behind the corresponding artery, and is covered by it at its lower part. At the point where the left common iliac vein joins the vena cava inferior, it is also crossed obliquely by the right common

* M. Bauer says, that he has seen valves in the venous vasa brevia of the stomach: I have never been able to discover them.

† [The escape of the mercury is due to rupture of the bloodvessels. In the villi, the minute branches of the vena portæ commence in the capillary network described and figured at p. 487. vol. i.]

iliac artery. It follows, therefore, that the left common iliac vein is covered, and may be compressed by both common iliac arteries, whilst the right common iliac vein cannot be compressed by either of them, and probably this is partly the reason why anasarca of the left lower extremity is more common than in the right extremity in atonic diseases.

The right common iliac vein receives no collateral branch; the left common iliac (*n*, *fig.* 223.) is joined by the middle sacral vein (*h*).

The *middle sacral vein* is situated in the median line, and its size depends upon that of the artery of the same name; it belongs to the rachidian veins, with which it will be described.

The Internal Iliac Vein.

The *internal iliac* or *hypogastric vein* exactly represents the internal iliac artery, on the inner side of which it is situated, separated from it, however, by a very thin fibrous layer, which holds it down against the walls of the pelvis.

The internal iliac vein receives the venæ comites of the branches of the internal iliac artery, the umbilical arteries in the fœtus alone being excepted; for their satellite vein, the umbilical vein, which is also peculiar to the fœtus, terminates in the hepatic portion of the vena portæ, as we have already seen.

The internal iliac vein, therefore, receives the blood returned from the parietes of the pelvis, from the organs contained within the cavity of the pelvis, and from the external genitals. There are always two veins for each artery; but the two unite into a single vein at their point of termination in the principal trunk.

The veins belonging to the parietes of the pelvis, viz. the *gluteal*, *obturator*, and *sciatic* veins, are arranged precisely like the corresponding arteries. The *ilio-lumbar* and *lateral sacral veins* (*i*, *fig.* 223.) form part of the rachidian system, which will be specially described.

The veins belonging to the genito-urinary organs present a plexiform arrangement both in their trunks and in their roots, which deserves particular attention.

Some of the venous plexuses of the pelvis are found both in the male and female, as the *hæmorrhoidal*, whilst some are peculiar to one or the other sex, as the vesico-prostatic and the plexuses of the penis to the male, and the vaginal and uterine plexuses to the female.

The Hæmorrhoidal Veins and Plexuses.

The *hæmorrhoidal veins and plexus* form a venous network, surrounding the lower end of the rectum. They are formed by the *superior hæmorrhoidal veins*, which form the commencement of the inferior mesenteric, and by the *middle and inferior hæmorrhoidal veins*, which are branches of the internal iliac. We ought to notice in particular the submucous venous network near the anus. The plexus formed by it is analogous to that found in all other mucous membranes; its vessels are liable to become varicose, a condition which constitutes the greater number of hæmorrhoidal tumours

The Pelvic Veins and Plexuses in the Male.

Preparation. Introduce one injection-pipe into the corpus cavernosum, and another into the glans penis, and then push an injection simultaneously into both of them, and also into the crural vein.

The *superficial scrotal veins* terminate partly in the superficial veins of the perinæum, and partly in the external pudic branches of the femoral vein; they communicate with the superficial veins of the under surface of the penis.

The vesical veins, or vesico-prostatic plexus. The prostate gland and the neck of the bladder are covered by a very complicated plexus of veins, which be-

come exceedingly developed in chronic inflammation of the bladder; it receives the superficial veins of the penis, and gives off the vesical veins.

This plexus, which communicates with the hæmorrhoidal plexus behind, is supported by a very thick fibrous layer, which is continuous with the pelvic fascia, and which limits the degree of dilatation of the veins of the plexus in the same way as the dura mater limits the dilatation of the sinuses contained between its layers.

The veins and plexuses of the penis. The *veins of the penis* are divided into a *superficial* and *deep* set, the former representing the subcutaneous veins of the limbs. They commence in the skin of the prepuce, and run backwards along the upper and lower surfaces of that organ. The superior are called the *dorsal veins of the penis;* they communicate freely with each other by large branches; most of them run beneath the arch of the pubes, between it and the corpus cavernosum, passing through some openings or fibrous canals in the sub-pubic ligament, which have the effect of keeping the veins always open; they end by assisting in the formation of the prostatic plexus. These veins communicate freely with the deep veins, especially opposite the junction of the two crura of the corpus cavernosum: this communication is proved by the fact that the superficial vessels are always filled when the injection is thrown into the deep veins.

The areolar tissue of the corpus cavernosum and that of the corpus spongiosum may be regarded as composed of a venous network or plexus at its maximum of development. Branches proceed from this plexus, which correspond to the divisions of the internal pudic artery, and follow the same course.

These veins, and the vesico-prostatic plexuses, are liable to become varicose; hard earthy concretions, called phlebolites, are also frequently found in them.

The Pelvic Veins and Plexuses in the Female.

The *vesical,* or *vesico-urethral plexus* of the female is less developed than that of the male, on account of the absence of veins corresponding to the superficial veins of the penis, which are represented by a few branches from the labia majora. This plexus communicates with the veins of the clitoris, and also very freely with the vaginal plexus behind.

The *vaginal plexus* is a vascular network, extremely well developed, especially opposite the orifice of the vulva, which is entirely surrounded by it with several series of circular anastomosing veins: it communicates with the vesical plexus in front, and with the hæmorrhoidal plexus behind; so that all the plexuses in the pelvis are involved in the state of turgescence, which accompanies the phenomenon of erection in the female. The radicles of this vaginal plexus commence in the mucous membrane of the vagina, and especially in the erectile tissue surrounding the orifice of that canal; some large veins arise in particular from the bulb of the vagina, forming a true erectile apparatus, which we have already described. (See SPLANCHNOLOGY, p. 625.)

The uterine plexus. The veins contained in the substance of the walls of the uterus do not present any trace of the tortuous arrangement of the corresponding arteries. In order to obtain a satisfactory idea of them, they should be studied in a gravid uterus. The uterine veins, like the uterine arteries, are then found along the sides and upper angles of the organ; opening into these veins are found larger venous canals, which run from side to side through the substance of the uterus, and anastomose frequently with each other. These venous canals are called the uterine sinuses, on account of their great size during gestation, and from the dilatations presented by them at the confluence of several secondary veins: they are also entitled to be so named from their structure, which has some analogy with that of the sinuses of the dura mater, inasmuch as only the lining membrane of the veins is prolonged into them; their outer coat is formed by the proper tissue of the uterus,

and hence the walls of these veins are contractile. I have stated elsewhere, that, in reference to its veins, we may consider the uterus as consisting of an erectile tissue with muscular walls; it is scarcely necessary to add, that these sinuses are unequally developed in different parts of the uterus, and that the point to which the placenta has been attached may be recognised by the greater size of the adjacent uterine sinuses.

The veins contained within the substance of the walls of the uterus do not open into the uterine veins alone; several of them terminate in the ovarian veins, which communicate freely with the uterine, and may, if necessary, supply their place.

The great size acquired by the uterine veins, both in the substance and on the surface of the uterus, proves that the venous apparatus plays an important part in the interstitial developement of this organ.

Moreover, the size of the veins and venous plexuses belonging to all the genito-urinary organs, and the essentially venous structure of such organs as are capable of being erected, prove that the venous system performs an essential part in the truly active phenomena of erection. It is partly upon these anatomical and physiological arguments that I have endeavoured to show the active part performed by the veins in all the great phenomena of the economy, such as nutrition, secretion, inflammation, &c.

The pelvic veins are provided with a great number of valves, which prevent injections from passing from the heart towards their extremities; it ought to be remembered, that the venous plexuses of the pelvis establish a very important and very free communication between the veins of the right and left sides of the body.

The Deep Veins of the Lower Extremity.

The veins of the lower extremities, like those of the upper, are divided into the deep veins or venæ comites of the arteries, and the superficial veins.

The Plantar, Posterior Tibial, Peroneal, Dorsal, Anterior Tibial, and Popliteal Veins.

The *external* and *internal plantar* veins unite to form the *posterior tibial*, which accompanies the artery of that name, and soon joins the *peroneal* vein, to constitute the *tibio-peroneal* vein: again, the *anterior tibial vein*, which commences by the *vena dorsalis pedis*, perforates the upper part of the interosseous ligament, joins the tibio-peroneal vein, and in this way forms the *popliteal* vein. Up to this point there are two venæ comites for each artery, one of the veins being placed on each side of the artery, across which they very frequently send communicating branches. The peroneal veins are generally larger than the posterior tibial, and receive all the muscular veins from the posterior and outer regions of the leg.

Commencing with the popliteal, there is only one vein for the main artery of the limb; but the arteries of the second and third order always have two veins.

The *popliteal vein* is situated in the popliteal space, behind and in contact with the artery. Its coats are remarkably thick, so that when cut across it remains open, and in the dead body has been sometimes mistaken for the artery. Below, and opposite the articulation of the knee, the vein is situated immediately behind the artery, above the joint it is behind, and a little to the outer side.

The popliteal vein receives the large bundles of veins, the sural veins, from the *gastrocnemius* muscle: they are remarkable for the number of their valves; also the *articular* veins, and generally the external saphenous vein. I have seen a small vein having very numerous valves, and being analogous to the

collateral venous canals of which I have already spoken, extend from the upper part of the anterior tibial to the middle of the popliteal vein.

The Femoral Vein.

The femoral vein, like the artery of that name, is bounded below by the ring in the tendon of the adductor magnus, and above by the crural arch; it has different relations with the femoral artery in various parts of its course: thus, below, it is on the outer side of the artery; higher up, it is situated behind that vessel; lastly, from the entrance of the vena saphena interna to the crural arch, it is placed to the inner side of the artery, and is in close contact with the posterior part of the opening for the femoral vessels; so that femoral herniæ descend in front of the vein, but not of the artery. The femoral vein is single, like the artery; nevertheless, there are one or two collateral venous canals, which run parallel with the lower half, or lower two-thirds of that vein; some communicating branches from the internal saphenous vein, and some muscular branches, open into these venous canals, which are always abundantly supplied with valves.

The femoral vein receives all the branches corresponding to the divisions of the femoral artery, excepting the external pudic veins and the cutaneous veins of the abdomen, which terminate in the internal saphenous vein.

The great deep vein (*profunda*) opens into the femoral about ten or twelve lines below the crural arch.

The External Iliac Vein.

The *external iliac vein* is bounded below by the femoral arch, and terminates at the upper part of the sacro-iliac symphysis by uniting with the internal iliac vein; it has the same relations as the artery, and is placed behind and to the inner side of that vessel, excepting over the os pubis, where it is exactly to the inner side of the artery. In one case I found the left common iliac receiving the right internal iliac, so that the right external iliac was prolonged into the vena cava.

The external iliac receives the epigastric and the circumflex iliac veins. These two veins are double, but each pair unites into a single trunk, as it is on the point of opening into the external iliac vein.

All the deep veins of the lower extremity, excepting the external iliac, are provided with valves. There are four in the deep femoral, the same number in the popliteal, and many more in the tibial and peroneal veins; the mouths of all the small veins which open into them are provided with a pair of valves.

The Superficial Veins of the Lower Extremity.

The superficial veins of the lower extremity are much less numerous than those of the upper, and all terminate in two trunks, viz. the *internal saphenous vein* and the *external saphenous vein.*

As in the hand, they are all situated upon the dorsal region of the foot. All the collateral veins of the toes enter the convexity of a venous arch, which is more regular and constant than that in the hand, and which is placed on the fore part of the metatarsus. From the inner end of this arch is given off a large branch, named the *internal dorsal vein of the foot*, which is the origin of the internal saphenous vein; the outer extremity also gives off a somewhat smaller branch, called the *external dorsal vein of the foot*, which forms the commencement of the external saphenous vein.

The Internal Saphenous Vein.

The internal or great saphenous vein (*saphena interna; s*, in the representation of the superficial nerves of the leg) is a collateral vein of the femoral venous trunk, and is continuous with the *internal* dorsal vein of the *foot.* The

last mentioned vein commences at the inner extremity of the dorsal venous arch of the foot, into which the collateral veins of the great toe open; it runs along the dorsal surface of the first metatarsal bone and the corresponding part of the tarsus, and receives, during its course, a deep branch from the internal plantar vein and all the superficial veins of the internal plantar region, and particularly the *internal calcaneal vein*, which is sometimes large, and which, in certain cases, does not terminate in the saphenous vein until it has reached above the internal malleolus, around the posterior border of which it turns. The internal saphenous vein succeeds to the one just described; it is reflected upwards in front of the internal malleolus, and continues to ascend upon the inner surface, then along the posterior border of the tibia, and upon the back of the internal tuberosity of that bone and the internal condyle of the femur. In this place it is situated on the inner side of the tendons of the semi-tendinosus, gracilis, and sartorius; it then inclines forwards describing a slight curve, with its concavity directed forwards; ascends along the anterior border of the sartorius, and crosses obliquely over the adductor longus; having arrived at the saphenous opening in the fascia lata, about eight or ten lines below Poupart's ligament, it immediately curves backwards, passes through that opening, and enters into the femoral vein, just as the vena azygos enters into the superior vena cava, that is to say, it describes a loop having its concavity directed downwards. Several lymphatic glands are found near this curve.

Relations. The internal saphenous vein is separated from the skin by a very thin fibrous layer, the superficial fascia, and is in relation with the internal malleolus, the tibia, the tibial origin of the soleus, the tendons of the semi-tendinosus, gracilis, and sartorius, with the last named muscle itself, and with the adductor longus. It is accompanied by the internal saphenous nerve, from the knee down to the internal malleolus.

During its course it receives all the subcutaneous veins of the thigh, most of the subcutaneous veins of the leg, the subcutaneous veins of the abdomen, the external pudic veins, and several communicating branches from the deep veins.

The *subcutaneous femoral veins* of the back of the thigh sometimes unite into one rather large trunk, which appears like a *second internal saphenous vein*; it runs parallel with the regular vein, and enters it at a greater or less distance from its termination. I have met with an anterior superficial vein which commenced around the patella, ascended vertically along the anterior region of the thigh, and might be regarded as a third saphenous vein. In one case of this kind, these three saphenous veins, viz. the anterior, posterior, and internal, entered separately into the femoral vein, or rather into a dilatation in which the internal saphenous vein terminated.

The internal saphenous vein often presents the following arrangement — opposite the lower part of the leg, or at the lower end of the thigh, it divides into two equal branches which pass upwards, communicate with each other by transverse branches, and unite after running a variable distance; in these cases the two branches represent a very elongated ellipse. I have even seen this arrangement in both the thigh and leg of the same subject, that is to say, the saphenous vein divided into two branches in the leg, which united opposite the internal tuberosity of the tibia, and again divided in the thigh.

It is not uncommon to find a venous network supplying the place of the internal saphenous vein in the thigh.

The *subcutaneous abdominal veins* should be arranged amongst the superficial and supplementary veins, although there is a small artery, the superficial epigastric, which corresponds to them. There are three or four of these veins, which are joined by one from the gluteal region; they open sometimes by a common trunk, sometimes by three or four distinct trunks, into the internal saphenous, just as that vein is passing through the fascia lata. In a case of obliteration of the vena cava I found these veins very large, and prolonged over the thorax into the axilla, where they anastomosed with the cutaneous

branches of the intercostal and thoracic veins. In a case in which the umbilical vein was persistent, the right and left internal saphenous veins were tortuous, and as large as the little finger.*

The internal saphenous also receives the *external pudic veins;* and I have seen it joined by the obturator vein, which commenced by a common trunk with the epigastric.

The *communicating branches of the internal saphenous with the deep veins* are very numerous, and should be studied in the foot, the leg, and the thigh. The origin of the internal saphenous vein gives off a branch, which communicates with the internal plantar vein.

Along the leg several other branches exist, which establish a communication between the internal saphenous and the posterior tibial veins; these branches perforate the tibial origins of the soleus muscle.

There is a very remarkable communication between the anterior tibial and internal saphenous veins in the middle third of the leg, by means of a branch which proceeds from the anterior tibial vein in front of the fibula, becomes subcutaneous, is reflected inwards and upwards between the fascia of the leg and the skin, and terminates in the internal saphenous.

Again, an inferior, internal, articular vein enters the internal saphenous.

Lastly, the anastomoses in the thigh, between the deep and the superficial veins, are less numerous than those in the leg; at most we only find two such describing loops with the concavity directed upwards.

Valves. The number of the valves appears to me variable: I have counted six along the internal saphenous, but at other times I have not found more than two or four. There is a greater number of valves in this vein in the thigh than in the leg.

The External or Posterior Saphenous Vein.

The *external saphenous* vein (la péronéo-malleolaire, *Chauss.;* see figure of nerves of leg), smaller and much shorter than the internal saphenous, is a branch of the popliteal vein; it forms a continuation of the *external dorsal vein of the foot,* which commences from the outer extremity of the dorsal venous arch; it passes behind the peroneo-tibial articulation, crossing it from before backwards; it receives as it runs outwards a great number of branches, the chief of which come from the external plantar region; also an external calcaneal vein, which is sometimes of considerable size, and comes from the outer side of the os calcis; the vein then runs along the outer border of the tendo Achillis, and crosses it at a very acute angle, to reach the middle line of the posterior aspect of the leg: commencing at this point, it passes directly upwards, crosses the internal popliteal nerve, and terminates in the popliteal vein between the internal and external popliteal nerves, between the two heads of the gastrocnemius, and by the side of the internal inferior articular vein.

In some subjects the external saphenous, at the moment when it bends to dip into the popliteal space, gives off an ascending vein, which runs along the posterior border of the semi-membranosus muscle, as high as the upper third of the thigh, where it then turns forwards to open into the internal saphenous, or one of the branches of that vein, immediately below its opening into the femoral.

Relations. The external saphenous vein is covered by the superficial fascia, which separates it from the skin, and it covers the external saphenous nerve, from which it is separated by a layer of fascia; it crosses this nerve twice, being at first situated to the inner side, then to the outer side, and again on the inner side of the nerve.

The external saphenous vein communicates with the deep veins only, behind the external malleolus, and upon the dorsum of the foot.

This vein has only two valves, one of which is situated immediately before its opening into the popliteal vein.

* Anat. Path. liv. xviii.

Such are the veins of the lower extremity. The analogy which exists between the internal dorsal branch of the foot and the cephalic vein of the thumb, between the external dorsal branch and the vena salvatella; between the external saphenous and the radial and cephalic veins; between the internal saphenous and the ulnar and basilic veins, cannot be doubted. There is no branch in the lower extremity analogous to the median vein.

THE VEINS OF THE SPINE.

General remarks. — The Superficial Veins of the Spine. — The Anterior superficial spinal veins, viz. the greater azygos — the lesser azygos — the left superior vertebro-costals — the right vertebro-costals — the vertebro-lumbar — the ilio-lumbar, and middle and lateral sacral — the anterior superficial spinal veins in the neck.— The Posterior superficial spinal veins.— The Deep Spinal or Intra-spinal Veins — the anterior longitudinal, and the transverse veins or plexuses, and the veins of the vertebræ — the posterior and the posterior and lateral transverse veins or plexuses — the medullary veins. — General remarks on the veins of the spine.

The spinal or *rachidian veins* constitute a very important part of the venous system, which has only recently been specially studied.

These veins differ, in many respects, from the spinal arteries, so that the description of the one does not afford much assistance in the study of the other; nevertheless, I shall frequently have occasion to point out some remarkable analogies between these two sets of vessels.

The spinal veins are arranged most distinctly as venæ comites and supplementary veins.

We shall divide them into the veins *exterior* to the spine or the *superficial* veins, and the *veins in the interior* of the spinal canal or the *deep veins*.

The Superficial Veins of the Spine.

The superficial veins of the spine may be subdivided into the *anterior* and *posterior*.

The Anterior Superficial Rachidian Veins.

The anterior *superficial rachidian* or *spinal veins* (see *fig.* 223.) comprise the vena azygos major, the vena azygos minor, the common trunk of the right superior intercostals, that of the left superior intercostals, the vertebro-lumbar and ilio-lumbar veins, and the lateral and middle sacral veins; in the neck, the ascending cervical and the vertebral veins.

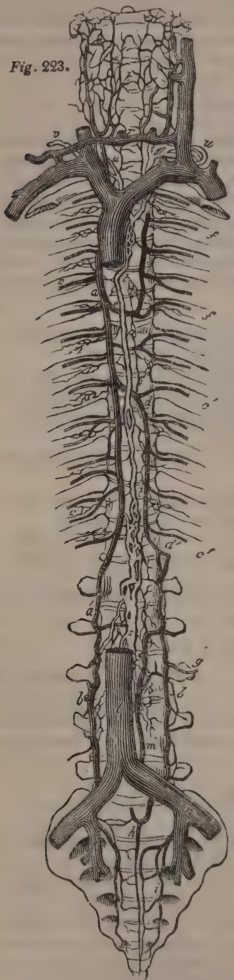
The Greater Azygos Vein.

The vena azygos major (*a a′*, *fig.* 223.) is a large single vein (ἄζυγος, *without a fellow*), situated along the vertebral column; it commences (*a′*) in the lumbar region, and terminates at the upper part of the thorax by opening into the vena cava superior.

Its *origin* is subject to much variety. It very rarely arises from the trunk of the inferior vena cava itself, with which, however, it almost always communicates by small branches. It generally forms the continuation of a series of anastomoses, which surround the bases of the right transverse processes of the lumbar vertebræ, and which may be called after some authors the *ascending lumbar vein* (*b*, on the right side); sometimes it arises from the trunk of the last vertebro-costal, or the first vertebro-lumbar vein: we rarely find a branch of origin from the renal or suprarenal veins. It often has two origins, one from the ascending lumbar, and the other from the first vertebro-lumbar, or last vertebro-costal vein. The vena azygos, almost immediately after its origin, passes from the abdominal into the thoracic cavity, through the aortic opening

in the diaphragm, ascends upon the right side of the bodies of the thoracic vertebræ, as high as the third intercostal space, *i. e.* between the third and fourth ribs, where it curves forwards, forming, like the aorta, an arch, which passes over and embraces the right bronchus, and opens into the back of the vena cava superior, as that vein is entering the pericardium.

Fig. 223.



During its course the vena azygos is in contact with the vertebral column, and is situated in the posterior mediastinum, on the right side of the aorta and of the thoracic duct ($t\,t$), which runs parallel to it; it lies in front of the right intercostal arteries, and crosses them at right angles. It varies in size, according to the number of branches which it receives, but gradually increases from below upwards.

The question of the existence of valves in the vena azygos has given rise to much discussion. It appears to me to be settled in the negative.

The vena azygos is joined in front by the *right bronchial vein* and some *œsophageal* and *mediastinal veins*; on the right side by the eight inferior *vertebro-costal veins* ($c\,c$) of that side; and on the left by the *lesser azygos* (d) and the common trunk (e) of the *left superior intercostal veins.*

Before opening into the superior vena cava opposite the third intercostal space, the azygos vein receives at its curve, either by a common trunk, or by two or three separate branches, the three superior right vertebro-costal veins, which sometimes enter the right brachio-cephalic vein, and sometimes the vena cava superior, above where it is joined by the vena azygos. In the last case they pass vertically upwards; in the second they are directed almost vertically downwards.

The Semi-azygos, or Lesser Azygos Vein.

The *lesser azygos vein* ($d\,d'$, azygos minor, semi-azygos) may be regarded as the common trunk of the three, four, or five inferior vertebro-costal veins ($c'\,c'$) of the left side: it opens into the great azygos vein.

It commences below (d') in as many different ways as the great azygos vein, but it communicates with the renal vein much more frequently. It runs upwards upon the left of the vertebral column, approaches the median line, and opens into the great azygos at a different height in different subjects. It joins the great azygos either at right angles or obliquely, passing behind the thoracic duct. The lesser azygos vein may be regarded as the left branch of origin of the greater azygos: sometimes it is extremely large; in that case the greater azygos is directly continuous with it, and the right branch is very small.

The lesser azygos vein is joined by the four or five inferior vertebro-costal veins ($c'\,c'$) of the left side. It also frequently receives the common trunk of

the superior vertebro-costal veins, which might be said to form a superior lesser azygos vein.

The Left Superior Vertebro-costal Veins.

The common trunk (*e*) of the left superior intercostal veins (*ff*) might be called the *left superior lesser azygos*, for it has the same relation to these veins that the lesser azygos has to the inferior intercostals of the same side. It runs downwards upon the left of the vertebral column, increasing in size as it approaches its termination, which is either near the end of the lesser azygos, or in the greater azygos. Not unfrequently the common trunk of the left superior intercostals bifurcates and opens both into the lesser azygos and into the left brachio-cephalic vein. In some cases it terminates entirely in the left brachio-cephalic vein: I have myself met with this disposition. I have seen the left superior phrenic and the mediastinal veins enter the trunk of the lesser vena azygos immediately before its termination.

The number of the left vertebro-costal veins which unite to form the lesser azygos vein, varies from three to seven; when only three or four of the highest of these vertebro-costal veins end in it, the two or three lower ones enter directly into the greater azygos vein.

General remarks on the vena azygos major. This vein returns the blood of the right and left vertebro-costal veins to the heart; its presence is rendered necessary, first, in consequence of the inferior vena cava not being able to receive any veins from the point where it enters the groove in the liver to its termination in the right auricle; and, secondly, because the superior vena cava is also unable to receive any veins whilst it is within the pericardium. The greater azygos is, therefore, a supplementary vein, a true collateral canal which supplies the place of the venæ cavæ, and receives all the veins corresponding to the branches given off by the aorta during this long course. These observations are, for the most part, applicable to all the azygos veins.

Anatomical varieties of the azygos veins. It would be both useless and tedious to notice here all the varieties that have been observed in the distribution of the azygos veins. M. Breschet has described six, but there are many more. The following is a very curious variety: the greater azygos occupies the median line of the dorsal portion of the vertebral column, and is divided below into two equal branches, a right and a left, each of which receives the three inferior vertebro-costal veins of its own sides; all the other vertebro-costal veins end directly in the greater azygos.

Another not less curious variety is the following: there are two equal and parallel azygos veins, a right, which receives all the right intercostal veins, and a left, which receives all the left intercostals: the two main trunks communicate with each other opposite the seventh or eighth dorsal vertebra by a very large transverse branch.

The Intercostal or Vertebro-costal Veins.

The *intercostal* or *vertebro-costal veins* of both sides (*c c*, *c′ c′*, *f f*) correspond to the intercostal or vertebro-costal arteries, the distribution of which it is important to call to mind. We have seen that each of these arteries divides into two branches, an *intercostal* branch, properly so called, intended for the intercostal spaces; and a *spinal* branch, the dorsal division of which terminates in the spinal muscles and the skin, while its vertebral, or intra-spinal division is distributed to the vertebræ, to the spinal cord, and to its coverings. In like manner the *vertebro-costal veins* are formed by the junction of the spinal branch, to which we shall presently return, and the intercostal branch. These two sets of branches unite into a common trunk, the vertebro-costal vein, which passes transversely along the groove on the body of each vertebra, receives some veins from the bone in that situation, and enters at a right angle into the corresponding azygos vein.

The Lumbar or Vertebro-lumbar Veins.

In the lumbar region there are no azygos veins, and each vertebro-lumbar vein enters separately, or by a common trunk, with its fellow of the opposite side into the back of the vena cava inferior. Not unfrequently two of the vertebro-lumbar veins of the same side open by a common trunk; and it is not rare to find the left superior vertebro-lumbar vein enter the renal vein.

The vertebro-lumbar veins (*g*) are distributed very differently from the corresponding arteries. Opposite the bases of the transverse processes there are a series of anastomotic arches, which together constitute, on each side, an ascending branch, called the *ascending lumbar vein* (*b b*), which communicates above with the corresponding azygos vein, and below with the ilio-lumbar veins, and which might be regarded as a *lumbar azygos vein.* The trunks of the vertebro-lumbar veins proceed from this series of arches to the vena cava; and all the intra-spinal and dorsi-spinal veins terminate in it.

The Ilio-lumbar, Middle Sacral, and Lateral Sacral Veins.

The *ilio-lumbar vein*, which opens into the common iliac, is distributed like the artery of that name; it sometimes receives the last vertebro-lumbar vein; it is joined by the great veins which emerge from the lower inter-vertebral foramina of the lumbar vertebræ; by the branch which is continuous in front of the fifth lumbar vertebra, with the series of arches forming what may be called the *lumbar azygos;* and, lastly, by a communicating branch from the lateral sacral veins.

The *middle sacral* and *lateral sacral veins* represent the azygos veins in the sacral region; they are joined by all the dorsi-spinal branches passing out from the intervertebral foramina, and end in the common iliac veins.

The *middle sacral vein* (*h*) often commences below by three branches, a median in front of the coccyx, and two lateral and anterior branches. One of these joins the vesical plexus, whilst the other communicates with the hæmorrhoidal veins, and establishes a remarkable communication between the general venous system and the system of the vena portæ.

The middle sacral vein passes vertically upwards, somewhere near the middle line, and opens into the left common iliac vein (*n*) at a greater or less distance from its junction with the right common iliac. I have seen it bifurcate above to enter both common iliacs.

During its course it is joined opposite each vertebra by some transverse, plexiform branches, which establish a free communication between it and the lateral sacral veins, and which receive some large branches from the bodies of the sacral vertebræ. These transverse branches represent the vertebro-costal and vertebro-lumbar veins, which also receive the veins which issue from the bodies of the vertebræ, through the foramina, upon the inner surface of those bones.

The *lateral sacral veins* (*i*), of which there are always more than one on each side, are continuous with the dorsi-spinal veins, which emerge from the anterior sacral foramina; there are generally two, a superior, which enters the common iliac vein, and an inferior, which forms a very remarkable plexus, opposite the great sciatic notch, and ends in the internal iliac vein, or in its gluteal and sciatic branches.

The Anterior Superficial Spinal Veins in the Neck.

In the anterior cervical region we find transverse plexiform branches (*k*) opposite each vertebra, more particularly opposite the first and second; these plexuses open partly into the ascending cervical vein, which corresponds to the ascending cervical artery, but principally into the vertebral vein, which is contained within the canal formed by the series of foramina at the base of the transverse processes of the cervical vertebræ. These plexiform branches, which cover the sides of the bodies of all the vertebræ, are joined by the veins from the prævertebral muscles, by the articular veins, and by the anterior osseous veins from the bodies of the corresponding vertebræ.

The vertebral veins and the ascending cervical veins may therefore be said to represent the azygos veins in the cervical region.

The Posterior Superficial Spinal Veins.

The posterior superficial spinal veins commence in the skin, and in the muscles of the vertebral grooves: some of them closely accompany the arteries; for example, those that pass between the muscles of the vertebral grooves; the others have a peculiar distribution, and require a special description.

These veins, which are called *dorsi-spinales* by MM. Dupuytren and Breschet, form an exceedingly complicated network, the meshes of which surround the spinous processes and laminæ, and the transverse and articular processes of all the vertebræ: these meshes are more numerous in proportion as the injection is more perfect.

After a successful injection, we sometimes find along the summits of the spinous processes, especially in the dorsal and cervical regions, certain *median longitudinal veins*, from which the interosseous branches proceed. These latter run forwards, on each side of, and in contact with, the interspinous ligaments. Having reached the base of the corresponding spinous process, they pass outwards, opposite the intervals between the laminæ of the vertebræ, as far as the bases of the transverse processes, and then divide into two branches; one of these ascends, and anastomoses with the descending branch from the vein above; whilst the other branch descends, and anastomoses with the ascending branch of the vein below. It follows, therefore, that around the transverse processes and the laminæ of the vertebræ there is a series of venous circles, which communicate opposite each intervertebral foramen with the veins contained in the interior of the spine.

The posterior superficial spinal veins in the neck have a much more complicated arrangement, and indeed form a plexus. Moreover, we generally find, between the complexus and the semi-spinalis colli, two longitudinal veins, which appear to me to deserve a particular description, under the name of the *posterior jugular veins.*

The *posterior jugular veins* commence between the occipital bone and the atlas, pass tortuously out from the interval between these bones, run downwards and inwards, and opposite the spinous process of the axis the veins of the two sides anastomose by a transverse branch. They then change their direction, pass downwards and outwards, and having reached the lower part of the neck, turn forwards, between the seventh cervical vertebra and the first rib, and open into the back of the brachio-cephalic vein behind the vertebral vein. The two posterior jugular veins are therefore arranged in the form of the letter X.

The posterior jugular vein, which does not always exist, for its branches of origin sometimes remain separate, seems to be inversely proportioned to the vertebral vein, with which it communicates opposite each intertransverse space. It has appeared to me to communicate above with the deep occipital and the mastoid veins, with the veins situated in the spinal canal, and with the internal jugular vein. Throughout the whole of its course, it communicates freely, opposite each intervertebral foramen, with the veins contained in the interior of the spinal canal, and with the vertebral vein.

The Deep Spinal or Intraspinal Veins.

The *veins in the interior of the spine* comprise the proper veins of the spinal cord, and the veins situated between the bones and the dura mater, which are subdivided into the *anterior* and the *posterior longitudinal veins* or *plexuses*, and the *transverse veins* or *plexuses;* the latter establishing a free communication between all four of the longitudinal veins or plexuses, opposite each vertebra.

Before describing the veins situated between the bones and the dura mater, I must state in a few words what is the arrangement of the proper arteries of the vertebræ.

The spinal branches which are given off on each side of the body, by the vertebral artery in the neck, by the intercostal arteries in the back, by the lumbar arteries in the loins, and by the lateral sacral arteries in the pelvis, enter the spinal canal through the several intervertebral foramina, and then each of them divides into an ascending and a descending branch; the ascending branch runs upwards upon the lateral part of the body of the vertebra above, and anastomoses with the descending branch of the spinal artery above it, while the descending branch anastomoses with the ascending branch of the artery below. Each of the anastomotic arches thus formed has its concavity directed outwards; so that there is a series of arterial arches, united at their extremities, situated upon each side of the posterior surface of the bodies of all the vertebra. From the convexity of each arch two transverse branches are given off — one running above and the other below the small foramina upon the posterior surface of the body of the corresponding vertebra. The cribriform portion of the bone is thus surrounded by the arterial arches with their transverse branches; and from all points of the polygon which they form small arteries are given off, which penetrate into the substance of each vertebra, and anastomose with the arterial twigs that enter the anterior surface of the body of the vertebra.

The arrangement of these arteries gives a perfect idea of that of the veins known as the *anterior longitudinal veins* or *plexuses*, and of the *transverse plexuses*, which pass from one to the other.

The Anterior Longitudinal Intraspinal Veins or Plexuses, the Transverse Plexuses, and the Proper Veins of the Bodies of the Vertebræ.

Dissection. Remove the arches of the vertebræ, and the spinal cord and its coverings. The plexus may also be viewed from the front by carefully sawing through the pedicles, and then removing the bodies of the vertebræ.

The *anterior longitudinal plexuses*, described by Chaussier, but still more correctly by Breschet, form two venous trunks, named the *great anterior longitudinal veins*, extending from the foramen magnum to the base of the coccyx, one on each side of the posterior common vertebral ligament, and therefore upon the sides of the posterior surface of the bodies of the vertebræ, and on the inner side of their pedicles. These veins, improperly called *vertebral sinuses*, communicate together opposite each vertebra by a *transverse* plexus, situated between the body of the vertebra and the posterior common ligament. These longitudinal plexuses are less developed in the cervical and sacral regions. It is probable that in the neck their place is supplied by the vertebral veins.

It would be in vain to consider these plexuses as having a distinct origin, course, and termination; the description given above of the distribution of the arteries is applicable to the veins in every respect: thus, the venous plexuses are formed by a series of plexiform arches, which embrace the pedicles of each vertebra, have their concavity directed outwards, and their convexity inwards, and the extremities of which anastomose together opposite the inter-vertebral foramina, where they communicate with the branches on the outside of the spine, and assist in the formation of the vertebro-lumbar and vertebro-costal veins, and consequently of the azygos veins. From the convexity of each arch proceeds a transverse plexus, which goes to join with its fellow of the opposite side; and just as we have seen that the transverse arteries extending from one arterial arch to another give off branches to the bodies of the vertebræ, so, in like manner, the transverse venous plexuses receive the veins which emerge from the body of each vertebra.

The arrangement of the veins or plexuses just described explains the alternate enlargements and contractions observed in different parts of the anterior longitudinal plexuses. The rare interruptions, described by M.

Breschet, I believe to depend upon imperfect injections, which succeed so differently in different subjects.

The anterior longitudinal veins or plexuses cannot be regarded as *sinuses*, for they are not contained in a fibrous sheath, like the veins of the dura mater, nor are they reduced merely to the lining membrane of the veins. Notwithstanding their extreme tenuity, we can recognise an external coat, and the posterior common ligament does not cover them behind. Nor is the term sinus more applicable to the transverse plexuses, although they are situated between the bodies of the vertebræ and the posterior common ligament, for the ligament merely covers them without forming a sheath for them.

The proper veins of the bodies of the vertebræ. The foramina upon the posterior surface of the body of each vertebra, which are generally proportioned to the size of the vertebra, are principally intended for the proper veins of the bodies of their bones: the arteries are much smaller, and though they enter by the same openings, they occupy but a small part of their areas. These veins belong to that system of venous canals found in the substance of bones, which we have already noticed as existing in the bones of the cranium. Their chief varieties have been correctly described and delineated by M. Breschet. These venous canals, which are more developed in the old than in young subjects, occupy the centre of the body of the vertebra, and always run parallel to the upper and lower surfaces of the bone: they arise from all parts of the circumference of the vertebra, communicating with the veins which enter by the foramina on its anterior surface, and converge towards the principal foramen, or foramina, upon its posterior aspect. They frequently enter a semicircular canal, which has its convexity directed forwards, and gives off from its concavity a venous canal, which opens directly into the transverse plexus: the lateral veins of the body of the vertebra open into the extremities of this semicircular canal; whilst within the venous canals of the vertebræ the veins are reduced to their lining membrane, like the veins in the canals of the cranial bones.

The transverse plexuses therefore collect the blood from the bodies of the vertebræ, and transmit it to the anterior longitudinal plexuses.

The Posterior Intraspinal Veins or Plexuses, and the Posterior and Lateral Transverse Plexuses.

The *posterior intraspinal plexuses*, much smaller than the anterior, are situated one on each side between the vertebral laminæ and ligamenta subflava behind, and the dura mater in front. These veins are rarely injected along the whole length of the spine, and hence they sometimes appear to exist only in the dorsal region. They communicate opposite each vertebra, by means of *posterior transverse plexuses*, or by transverse veins. They communicate with the anterior longitudinal plexuses by small *lateral transverse plexuses*, which pass from behind forwards. It follows, therefore, that the veins within the spine, but external to the coverings of the cord, consist of four longitudinal plexuses, all of which are connected by a transverse circular plexus opposite each vertebra. A strict analogy may be said to exist between the sinuses of the cranium and the intraspinal plexuses; an analogy which did not escape the notice of the ancients, as the common application of the term sinus by them to the veins of the cranium and to those of the spine would seem to indicate. Thus, in the cranium we find certain *longitudinal sinuses*, that is, those which run from before backwards, viz. the superior longitudinal sinus, the straight sinus, and the posterior occipital sinuses; also, the superior and inferior petrosal sinuses, the cavernous sinuses, and the right and left lateral sinuses. The former set represent the posterior intraspinal plexuses; the latter correspond to the anterior intraspinal plexuses.

In the cranium we also find certain *transverse sinuses*, viz. the basilar or

transverse occipital sinuses and canals, and the coronary sinus, which exactly correspond to the transverse plexuses, extending from one anterior intraspinal plexus to the other. We sometimes find two or three transverse venous plexuses in the basilar groove of the occipital bone.

Lastly, may we not compare the veins on the outer surfaces of the spine to the occipital, frontal, and temporal veins; and do not the veins passing through the posterior lacerated foramen and the sphenoidal fissure, which we have regarded as representing the intervertebral foramina (see Osteology), establish a communication between the veins on the inside and those on the outside of the cranium, just as the veins which escape through the intervertebral foramina connect together the superficial and the intraspinal veins.

The anterior and posterior deep spinal veins communicate with the superficial veins of the spine at the intervertebral foramina so freely, that the circulation would not be interfered with even if a considerable amount of obstruction existed. I have already stated (see Vertebræ), that the diameter of the intervertebral foramina is in relation, not with the size of the nervous ganglia, but rather with that of the veins, which establish a communication between the superficial and intraspinal venous systems.

The Proper Veins of the Spinal Cord, or the Medullary Veins.

If we examine the pia mater of the spinal cord, even without having injected it, in the body of a person who has died suddenly, as in that of a newborn infant after death from asphyxia or apoplexy, the surface of the pia mater will be found covered by very tortuous veins, which emerge from the posterior median furrow of the spinal cord. This venous network, which is spread over the whole surface of the cord, gives off opposite the roots of each nerve a small vein, which runs directly between those roots, enters the corresponding intervertebral foramen, is enclosed with the nerve in the sheath formed by the dura mater, and having emerged from that sheath, opens into the large vein situated in the intervertebral foramen.

There is, therefore, this difference between the proper veins and arteries of the spinal cord, that the number of veins is equal to that of the nerves; whilst the arteries are less numerous, and enter the fibrous sheaths of the nerves only at intervals, and in proportion as the preceding arteries are exhausted. Moreover, the anterior and posterior spinal veins, like their corresponding arteries, may be regarded as belonging only to the upper part of the cord, and not as being intended to traverse its whole length.

General Remarks on the Veins of the Spine.

The veins of the spine may be regarded, in reference to the general circulation, as establishing an unbroken communication between the veins of all parts of the trunk; so that we can suppose one of the venæ cavæ to be obliterated, without the venous circulation being interrupted. The greater azygos itself, which is generally regarded as the principal means of communication between the two venæ cavæ, is not, however, necessary, when we consider the arrangement of the anterior and posterior spinal plexuses. Thus, I have sometimes seen the inferior, and sometimes the superior, vena cava obliterated without any apparent increase in the diameter of the vena azygos, and, what will perhaps be thought surprising, without œdema, either of the upper or lower extremities.

Supposing the vena cava ascendens to be obstructed from the entrance of the hepatic veins down to the renal veins, the blood would then flow back by the vertebro-lumbar veins into the plexuses contained within the spinal canal; through these plexuses, it would ascend to the vertebro-costal veins, from thence to the azygos veins, and through them into the superior vena cava.

If all the jugular veins were obliterated, the venous circulation in the head would still continue, and would be carried on through the spinal veins. I have

tied the two external jugular veins in a dog. The animal shewed no sign of cerebral congestion: after opening the body, I did not find any increase of size in the small veins which accompany the carotid arteries, and which in those animals are naturally very small. In this case, the circulation was evidently carried on by means of the spinal veins.

THE LYMPHATIC SYSTEM.

Definition, history, and general view of the lymphatic system. — Origin. — Course. — Termination and structure of the lymphatic vessels.—The lymphatic glands.— Preparation of the lymphatic vessels and glands.

The term *lymphatic vessels* is applied to certain transparent tubes provided with valves, and conveying either lymph or chyle, which pass through small, rounded, glanduliform bodies, called *lymphatic glands*, and in all cases empty themselves into the venous system, to which, indeed, they may be said to form an appendage.

From their tenuity and transparence, these vessels for a long time escaped the notice of anatomists. The thoracic duct was discovered by Eustachius in 1565. The lacteals were discovered in 1622 by Gaspard Asellius, who, by a lucky chance, whilst seeking quite another object, discovered certain vessels filled with chyle. In 1641, Pecquet discovered the receptaculum chyli, and showed that the lacteals entered the thoracic duct, and not the liver, as Asellius and all his contemporaries believed.

Rudbeck, Thomas Bartholin, and Jolyff dispute the honour of having discovered the lymphatic vessels, properly so called, in contradistinction to the lacteals, or chyliferous vessels.

Mascagni devoted a great part of his life to the study of the lymphatic system; and his work, ornamented by magnificent plates, is a monument of science, which should be taken for a model by all who are engaged in anatomical inquiries. Lastly, within the last few years, MM. Fohmann, Lauth, Lippi, Panizza, and Rossi have thrown light upon some most important points in the anatomy of this system.

In describing this system of vessels, the lacteals, or the lymphatics containing chyle, have commonly been separated from the lymphatics, properly so called, or the vessels containing lymph. This distinction, however, is not warranted by anatomy, for the two sets of vessels are perfectly identical in structure.

The lymphatic system offers many analogies with the venous system; but there are also no less remarkable differences between the two.

Like the venous system, it consists, as a whole, of afferent, or converging vessels, which arise from all parts of the body, and run from the periphery towards the centre.

Like the veins, the lymphatics are divided into two sets: a *subcutaneous* set, which, in general, accompanies the superficial veins of the limbs; and a *deep* set, which follows the course of the deep arteries and veins: and, lastly, the lymphatics resemble the veins, in being provided with valves.

The lymphatics differ from the veins in passing through certain bodies improperly called glands, which at intervals intercept their course. They differ from the veins, also, in their arrangement; for they do not successively unite into larger and larger branches, and these into trunks, but they scarcely increase in size from their origin to their termination; and, though they communicate with each other by numerous anastomoses, each of them follows, as it were, an independent course: lastly, the blood which circulates in the veins is still, though indirectly, under the influence of the heart's action, whilst the onward movement of the lymph is exclusively dependent upon the parietes of the vessels.

Before proceeding to the special description of the lymphatics, we shall make some general remarks upon the origin, course, and termination of these vessels.

Origin of the Lymphatics.

The origin of the lymphatics, like every point connected with the minute structure of the tissues, is yet a new subject for inquiry.*

It has been said that the lymphatics are continuous with the arteries, so that, according to this hypothesis, the arteries are continuous with two kinds of vessels, viz. with the lymphatics, which carry off the serum; and with the veins, which transmit the coloured part of the blood. The continuity of the arteries with the lymphatics has been admitted, in consequence of its having been observed that injections thrown into the arteries passed into the lymphatics. I have frequently seen this in injecting the spleen and the liver; but it was only when the injection was pushed in with great and continued force: so that it is possible, as thought by Hunter, Monro, and Meckel, that in these cases some of the vessels had been ruptured, and the injection extravasated; or, what is still more probable, there may have been transudation through the pores of the tissues. Microscopical observations show most distinctly that the arteries are continuous with the veins; but there is no fact to demonstrate the continuity of the arteries with the lymphatics.

The origin of the lymphatics can be actually shown only upon free surfaces, such as the mucous membranes, the skin, the serous and synovial membranes, and the lining membranes of arteries and veins; so that, in the actual state of our knowledge, it might be maintained that the lymphatic vessels arise exclusively from all the free surfaces.

All the lymphatics arise by a network of such tenuity, that, when injected with mercury, the whole surface appears changed into a metallic layer.

About eight years since, having introduced at random a tube filled with mercury for injecting the lymphatics, into the pituitary membrane in a calf, I was astonished to find the surface covered by a metallic pellicle: I repeated the experiment frequently, and constantly found that the pellicle was not caused by extravasation, for the mercury ran in determinate lines, forming plexuses of different kinds; also that, to succeed in this experiment, it was necessary to puncture the membrane very superficially, or the mercury would run into the subjacent plexus of veins; and, lastly, that there was no communication between that plexus of veins and the more superficial network, which I suspected to consist of lymphatic vessels, for it exactly resembled the network of those vessels in the peritoneum covering the liver. I ascertained that the same structure existed in the skin; in the lingual, buccal, and vaginal mucous membranes; in the conjunctiva; and, lastly, in the uterine mucous membrane of a sow, which had lately littered. I showed this lymphatic network of the pituitary membrane in several of my lectures; and lately having again examined the subject for the purposes of the present work, I have ascertained that this network exists upon all the free surfaces, that it communicates with the lymphatics, and that it is possible to inject those vessels and the lymphatic glands by introducing the pipe very superficially into the surfaces of these membranes.† I may be permitted to observe, that it is only a few months since I became acquainted with the splendid work of M. Panizza of Pavia, upon the lymphatic vessels of the testicles (*Osservazioni Antropo-zootomico Fisiologiche*, 1830); and with M. Fohmann's last very important memoir (*Mémoire*

* Do lymphatics commence in all parts of the body? It is true, that absorption is carried on in every part, for absorption is one element of the process of nutrition; but as it can be effected by other vessels besides the lymphatics, its occurrence in any part does not necessarily involve the presence of this peculiar class of vessels.

† These preparations were made by M. Bonami, my prosector, under my direction, with extreme skill, and a zeal above all praise.

sur les Vaisseaux Lymphatiques de la Peau, des Membranes Muqueuses, Séreuses, du Tissu Nerveux, et des Muscles, 1833).

Origin of the lymphatics from the mucous membranes. The villi found upon the mucous membrane of the small intestines contain, in their centre, a cavity, named the *ampulla of Lieberkuhn*, which I have seen in one instance filled with tuberculous matter. (*Anat. Pathol.* liv. ii.) Still I have never been able to discover any open orifice on the summit of that villus.* Independently of these cavities within the villi, which are proper to the system of lacteal vessels, the thin pellicle of the mucous membranes which cannot be injected from the arteries or veins (*vide* p. 427.), when carefully and very superficially punctured by the pipe of a mercurial injecting apparatus, is covered by a metallic pellicle. Panizza and Fohmann have proved that the membrane which covers the glans penis has two sets of lymphatics — a superficial and a deep. M. Fohmann has figured, in some very beautiful plates, the lymphatic network of the mucous membranes of the glans penis, bladder, urethra, trachea, bronchi, œsophagus, stomach, ileum, and colon. This network is so superficial, that the mercury appears almost uncovered; it does not communicate either with the arteries or the veins, but communicates freely with the lymphatic vessels. It was correctly delineated by Mascagni: according to that anatomist, it covers all the intestinal villi, as with a sheath, and does not appear to have any openings on the exterior.

Origin of the lymphatics from the skin. Are the openings or pores so evident upon the skin when viewed through a lens, and from which drops of sweat may be seen to exude, intended to serve the purpose both of exudation and absorption? or are there rather two distinct kinds of orifices for these two functions? or, lastly, are these orifices altogether unconnected with the absorbent vessels? †

If we puncture the skin very superficially, so that the injecting pipe may enter immediately below the epidermis, the mercury will be seen to run with great rapidity into some very small vessels, and to form a metallic network, precisely like that already described as existing in the mucous membranes; from this layer proceed subcutaneous lymphatics, which may be traced filled with mercury as far as the adjacent lymphatic glands, or even beyond them. In order that this experiment may succeed, it is necessary that the skin to be injected should be plunged into hot water.

I made the following experiment in order to detect, if possible, in the lymphatics of the skin, the mercury absorbed during mercurial frictions. I caused two dogs to be rubbed with mercurial ointment night and morning; and that the absorption might be more complete, I enveloped their bodies in a frock made of skin. These animals died in about eight days with gangrene of the gums; but I could not find in any part the slightest trace of mercury, although the frictions were continued up to the period of their death.

Origin of the lymphatics from the serous and synovial membranes. The same results as those above stated are obtained by injecting the serous and synovial membranes. The portion of peritoneum covering the liver is generally chosen for injecting the lymphatic network of serous membranes, because the tension and adhesion of the peritoneum over the liver renders it more easy to inject. The same results may be obtained by injecting the costal or pulmonary pleura, the tunica vaginalis, or the parietal and visceral portions of the arachnoid.

The *synovial* membranes may be injected with the greatest facility, either near the cartilages, where they are more tense than in other parts, or upon the ligaments, to which they adhere.

Origin of the lymphatics from the lining membrane of the veins and arteries. The lymphatic plexuses upon the lining membrane of veins and arteries have

* [For what is known concerning the structure of the villi, see note, p. 487.]

† [These pores are the orifices of the ducts of the sudoriferous glands, which are embedded in the true skin, or the subcutaneous cellular membrane, and have no direct connection with the lymphatics.]

hitherto been only partially displayed, but the analogy between these and serous membranes is so close, that I have no doubt of their identity in this respect. I have, moreover, found the lymphatic vessels of the aorta filled with blood in several cases of degeneration of the coats of that vessel.

Origin of the lymphatics in the free cellular tissue. In order to exhibit the origin of the lymphatics in this situation, I injected coloured liquids, such as ink, into the subcutaneous and intermuscular cellular tissue in several animals, and I found the lymphatic vessels, and the corresponding lymphatic glands, of a jet black colour. I made a great number of experiments to induce absorption of mercury, by injecting it either into the cellular tissue, or into a serous cavity; but the metallic mercury always acted like a foreign body, the mechanical effect of which produced more or less inflammation, but it was never absorbed.

I have found pus in both the superficial and deep lymphatics, and in the lymphatic glands of the groin, after phlegmonous erysipelas and acute abscesses of the leg; but it is not proved that the presence of this pus was the result of absorption. It is more probable that it had been produced by inflammation of the lymphatics themselves.

Although it is impossible to demonstrate, anatomically, the presence of lymphatics in the free cellular tissue, it is most probable that that tissue, as well as the serous membranes, with which it has so many analogies, is formed by this kind of vessels. Mascagni stated that all the white tissues consist of lymphatic vessels, and that the lymphatic system forms the basis of the whole body.

From the preceding observations it may be stated, that, with the exception of the lacteals which open upon the summits of the villi*, all the lymphatic vessels of free surfaces arise by an exceedingly delicate network; M. Fohmann believes that all the lymphatics commence by a network of closed vessels.†

I have never been able to discover the lymphatic networks, either in the nervous substance, in muscles, glands, or in the fibrous, cartilaginous, and osseous tissues.

Course of the Lymphatics.

From the networks above described, the *lymphatics* themselves arise, and, in all the organs, are divided into a *deep* and a *superficial* set. The former set accompany the deep vessels of the organ, whilst the others follow the superficial veins in such parts of the body as are provided with them. In those organs which are covered with a serous coat, they appear to be contained within the substance of that membrane. The lymphatics run parallel with each other, and communicate pretty frequently by bifurcating, and then joining the neighbouring vessels; but they do not converge towards each other, nor do they, like the veins, unite successively into a smaller and smaller number of larger and larger branches; thus their increase in size is not progressive; and it might even be said, that throughout their whole course they undergo no decided increase nor diminution.

Their *direction* is slightly tortuous. (In *fig.* 224. are shown short portions of lymphatics of different sizes.)

Anastomoses. We do not find in the lymphatics those numerous and important anastomoses which form such characteristic points in the history of the arteries and veins. These vessels present only one kind of anastomosis, which is accomplished in the following manner: a lymphatic, after a certain course, divides into two equal branches, which diverge at a very acute angle; these two branches anastomose with two other lymphatics, each of which communicates

* [Whether the lacteals commence in each villus by a *network*, or by free closed extremities, is not yet determined; but they form no exception to the rule that the absorbent vessels arise by *closed* extremities, and not by *open* mouths. See Vol. I. p. 487.]

† [These networks are arranged in layers, the most superficial of which is formed by the finest vessels, and has the smallest meshes.]

either by bifurcation, or directly with the neighbouring lymphatic vessel. This explains how, by injecting a single lymphatic, a certain group of these vessels may be filled. Not unfrequently a lymphatic divides into two branches, which, after a certain distance, again unite.

During their course, the lymphatic vessels meet certain small *glanduliform bodies*, the *conglobate glands* of the ancients, but which are also called *lymphatic ganglia*, on account of the analogy pointed out by Soemmerring between them and the ganglia of nerves; the lymphatic glands form centres, to which a number of lymphatic vessels proceed, and are lost in them for a time, but from which they afterwards emerge.

The name of *afferent lymphatics* (vasa afferentia, *a a a*, *fig.* 225.), is applied to those which enter a gland, and those which emerge from it are called *efferent lymphatics* (vasa efferentia, *b b*).

Do all the lymphatics necessarily traverse one or more of these glands? Mascagni has successfully maintained the affirmative in opposition to Hewson and others, who assert that they have seen lymphatics entering directly into the thoracic duct. Mascagni states, that he invariably found that these vessels passed through one or more glands. As to the argument derived from the absence of dropsy in cases of obstruction in the lymphatic glands, Mascagni explains this by the frequent anastomoses of the lymphatic vessels, the result of which is, that they communicate with several series of glands, some of which are situated at very great distances.

The most numerous anastomoses of the lymphatics take place within the lymphatic glands; thus, if we inject the afferent vessels of a lymphatic gland, the mercury escapes by its efferent vessels. In injecting a gland, it frequently happens, that the mercury passes not only into the efferent, but also into some of the afferent vessels.

Size of the lymphatics. The lymphatics are generally so small, as to escape the notice of the observer; but they may become enlarged to a remarkable degree. Thus, I have seen the lymphatics of the groin and of the uterus as large as the thumb.

An attempt has been made to draw some comparison between the total capacities of the lymphatic, venous, and arterial systems; but all that has been said respecting this is founded upon no positive data. I would moreover observe, that in all probability we are acquainted with but a portion of the lymphatic system.

Termination of the Lymphatics.

According to the most generally received opinion, all the lymphatics terminate in two trunks, the *thoracic duct* and the great *right lymphatic duct;* the latter vessel receives the lymph from the right upper extremity, and from the right half of the head, neck, and thorax; the lymphatic vessels of all the other parts of the body end in the thoracic duct; the lymphatic vessels enter successively into these two trunks, as the plumes of a feather are attached to its shaft. The two trunks themselves end as follows: the thoracic duct enters the left subclavian vein, at the junction of that vein with the internal jugular; the great right lymphatic duct terminates in the right subclavian vein; hence it is that the lymphatic system may be regarded as an appendage of the venous system.

Are the thoracic and the great right lymphatic ducts, notwithstanding their small size, the only terminations of the lymphatic system? With this question may be connected another—Are the lymphatics the exclusive agents of absorption, or do they share this function with the veins?

Mascagni appeared to have established beyond dispute, that absorption was performed by the lymphatics to the exclusion of the veins; when Magendie *

* It is established, says M. Magendie, that the lacteals absorb the chyle, and that the intestinal veins absorb other substances. It is shown that the veins are the absorbing agents in

and Delille in France, Tiedemann and Gmelin in Germany, and Flandrin and Emmert in England, relying upon some ingenious experiments, again attributed a power of absorption to the veins, and hence led other anatomists to undertake still further researches.

The inquiry was soon entered upon by M. Fohmann in 1820 and 1821, by M. Lauth in 1824, and by M. Lippi in 1825, all of whom again referred the phenomena of absorption exclusively to the lymphatics, and supported that opinion both by arguments and facts.

MM. Fohmann and Lauth admit two other modes of termination of the lymphatic system in the veins, besides the one already indicated: first, a direct termination of the lymphatic radicles in the radicles of the veins, which is supposed to occur in the substance of organs; and, secondly, a communication between the lymphatics and veins within the lymphatic glands. This opinion, which seems reconcilable with the fact, that the area of the thoracic and right lymphatic ducts is very small as compared with that of all the lymphatic vessels, appears, *à priori*, to be exceedingly probable.

But an anatomical fact must be shown anatomically, before it can be admitted. Now, there is no proof of the communication of the lymphatic and venous radicles. M. Fohmann relies upon certain more or less ingenious inductions; but not upon direct anatomical facts. I am, therefore, still compelled to doubt the existence of these communications, and to class them with the vasa serosa, or serous veins of Haller.

Again, a communication between the lymphatics and the veins in the substance of the lymphatic glands, had been conjectured by many anatomists; the elder Meckel had seen mercury, when thrown into the lumbar lymphatics, pass into the abdominal veins; but this fact was attributed to rupture in the interior of the glands. (*Hewson*, *Cruickshank.*) This apparent communication had also frequently been observed by Mascagni, and was attributed by him to rupture.

M. Fohmann urges in reply, that this communication takes place under too slight a pressure to be referred to rupture, that actual extravasations may be easily recognised, and that the mercury is then infiltrated into the cellular tissue with much greater facility than it can enter the veins. "Why," he asks, "supposing the existence of rupture, does the mercury never pass from the lymphatics into the arteries?" He also adduces in support of his opinion, a considerable number of facts, which show that injections thrown into the lymphatic glands, sometimes escape by the lymphatics alone, sometimes by the veins alone, and sometimes by both the lymphatics and the veins. He states that having emptied the veins passing out from a mesenteric gland in a horse which had been killed whilst digestion was going on, and having replaced the intestines in the abdomen, he found some streaks of chyle in the veins. Lastly, he has seen, in birds, the renal lymphatic vessels, which represent the lymphatic glands in those animals, opening directly into the renal and sacral veins. M. Lauth has repeated these experiments, and obtained the same results. But, however imposing the authority of the authors just cited may be, I must confess that I am far from being convinced, and that the facts stated by them do not appear to me to be conclusive. I have made a great number of injections of lymphatics, and, in by far the greater number of cases, the mercury passed from the afferent into the efferent lymphatic vessels, and not at all into the veins. In some cases it passed from the glands into the veins; but it appeared to me, that the glands had then undergone a change in their texture, more particularly a red softening.

It does not seem to me, then, to be shown that there is any direct communication between the lymphatics and the veins within the substance of the lymphatic glands.

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other parts of the body; but it is not shown that the lymphatics absorb. Some authors have stated that the veins absorb only when the lymphatic system is diseased.

Lippi (of Florence) denies the communication of the lymphatics with the veins within the lymphatic glands; but believes that, besides the terminations of the lymphatics in the venous system through the thoracic duct and the great right lymphatic trunk, there are a great number of direct communications between the lymphatics and the vena portæ, the internal pudic and the renal veins, and the vena cava ascendens and vena azygos.

Several anatomists, indeed, had already met with lymphatic vessels opening directly into the venous system; among whom were Walœus, Wepfer, Abraham Kaw, Hebenstreit, the elder Meckel, Caldani, and Vrolyk; but the isolated facts recorded by them were regarded by Haller, Mascagni, and Soemmerring as anomalies, or as the results of rupture.

The memoir published by Lippi excited new investigations on all sides. I was the more inclined to subscribe to the opinion of that observer, because, in 1825, I had most distinctly seen a large lymphatic trunk opening directly into the external iliac vein; because it appeared to me rational to admit, that the communications between the lymphatic and venous systems would not be restricted to the internal jugular and subclavian veins; because the communications supposed to exist by Fohmann and Lauth had not been demonstrated; because ligature of the thoracic duct does not prove fatal to all animals subjected to that experiment, even when the duct is single; and, lastly, because the thoracic duct has been found obliterated in many individuals. There seemed, besides, a difficulty in admitting that the thoracic and right lymphatic ducts formed the termination of the whole of the lymphatic vessels. It appeared, moreover, at variance with the general laws of the animal economy to suppose that two sets of organs should be devoted to the same functions; for if the veins absorb, the lymphatic system would seem to have no special use.

Nevertheless, truth compels me to state, that, after the most minute and frequent researches which I have been able to make, I have not obtained a single result confirmatory of the statements of M. Lippi; and that, with his plates before me, I have searched for the communications in all the points which he has indicated, and have never found any. I am, therefore, obliged to conclude with MM. Rossi, Fohmann, and others, that the vessels which M. Lippi has described as lymphatics opening into different parts of the venous system, are nothing more than veins.

Structure of the Lymphatics.

The lymphatics, as well as the veins, have two coats. This structure can be readily shown in the thoracic duct of the human subject, and still better in that of the horse: the existence of these two coats may also be shown by a method suggested by Cruickshank, which consists in turning the thoracic duct inside out, and forcibly introducing a tube into it; the lining membrane, which is then on the outside, being less extensible than the external coat, becomes lacerated.

The *external coat* is considered to be fibrous by some, and muscular by others. Sheldon says, that he has distinctly seen muscular fibres arranged circularly around the thoracic duct of the horse. It appears to me, that this external coat resembles the dartoid tissue like the outer coat of the veins. It is not uninteresting to remark, that the outer surface of the lymphatics is often covered by a thin layer of fat, which has deceived several anatomists.

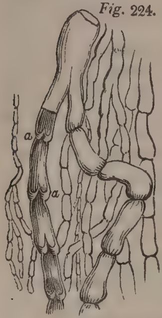
The *internal coat* of the lymphatic vessels appears to be of a serous nature like that of the veins. Some arterial and venous twigs ramify in their parietes; but no nerves have yet been traced into them. Minute lymphatics probably arise from the coats of the larger ones. Mascagni believes that their lining membrane is entirely lymphatic.

Notwithstanding their excessive tenuity, the lymphatics are tolerably strong, less so, however, than is generally stated, for they are often lacerated by the

weight of a small column of mercury. They do not appear to me to be stronger than the veins. They are much less extensible When the thoracic duct, or any other lymphatic vessel is punctured, it immediately collapses and forces out its fluid contents sometimes in a jet. Some admit the existence of muscular contractility in them. The vermicular motion caused by contraction of their external coat is sufficient to explain the above-named fact.*

The lymphatics are much more abundantly supplied with valves than the veins. The valves (*a a, fig.* 224.) are parabolic, and are arranged in pairs; they have an adherent border turned towards the commencement, and a free border towards the termination of the vessel; they are generally situated at very short intervals apart, as is shown by the knotted appearance of the vessels (see *fig.* 224.), and occasionally they present a circular or annular arrangement, from which they have been regarded as true sphincters.

Fig. 224.



In general, these valves are strong enough to prevent the retrograde course of the lymph, and consequently of injections also. Nevertheless, Hunter inflated all the lacteals from the thoracic duct; Haller filled all the lymphatics of the lung from the upper part of the same canal, and Marchettis says that he has injected the whole of the lymphatics from the reservoir of Pecquet. The valves are extremely numerous in the lymphatics; they have sometimes appeared to me to be wanting in the thoracic duct. Like those of the veins, the valves of the lymphatic vessels appear to be formed by a fold of the internal membrane.

The Lymphatic Glands.

Sylvius was the first to distinguish the lymphatic glands under the term *conglobate glands*, from the glands properly so called, which he named *conglomerate*. Chaussier called these little bodies *lymphatic ganglia*, following Soemmerring, who first pointed out the analogy between them and the venous ganglia.

The lymphatic glands are situated along the course of the lymphatic vessels, in reference to which they may be regarded as centres in which a certain number of the vessels open; those of the extremities are chiefly found at the upper part of the limbs on the aspect of flexion; those of the thorax, the abdomen, the head, and the neck are placed along the vertebral column and the great vessels; they are found also in the substance of the mesentery, in the mediastina, at the roots of the lungs, &c.

Their *size* varies from that of a millet seed to that of a large filbert. The smallest are situated in the epiploon; the largest at the roots of the lungs. They are often greatly enlarged by disease. They are generally of a reddish grey *colour*, excepting at the root of the lungs, when they are black. Their form is irregularly spheroidal; and they have been distinctly shown by Malpighi to have a cellular structure.† If we examine with a lens a lymphatic gland distended with fluid, we observe that it contains cells; the same fact is clearly demonstrated by injecting it with mercury, which shows, moreover, that the cells communicate freely with each other. It is nevertheless doubtful whether all the cells communicate. The researches which I have made upon this subject appear to show that each lymphatic vessel is connected with a distinct

* [The lacteal vessels have been seen to undergo a *slow* contractility on exposure to air, or to the action of any other stimulus; but there is no evidence of the muscularity of any part of the lymphatic system of mammalia. In certain reptilia and amphibia there are pulsating muscular sacs connected with the lymphatic system, which are called *lymphatic hearts*.]

† See note, *infrà*.

portion of the lymphatic gland; and diseases of the glands establish the same fact, by attacking one part only of a gland, the rest continuing unaffected.

Several lymphatic vessels enter each gland, and several emerge from it. Each afferent vessel (*a a a*, *fig.* 225.), as it reaches the circumference of the gland, divides into a considerable number of branches, which diverge and run for a short distance upon the surface of the gland, and then dip into its substance.* The efferent lymphatics (*b b*) commence in precisely the same manner as the afferent vessels terminate.

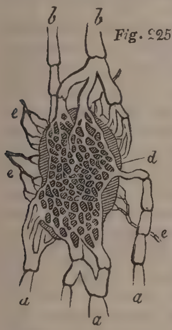


Fig. 225.

The study of these vessels in the larger animals appears calculated to clear up all doubts as to the structure of the lymphatic glands. Abernethy having injected the mesenteric arteries and veins of a whale, saw the fluid run into pouches about the size of an orange; he then injected mercury into the lacteals, and found that it flowed into the same cavities; he therefore concluded that the arteries, veins, and lacteals all opened into the same cavities. This fact appears to confirm the observations quoted by MM. Fohmann and Lauth, relative to the communications of the lymphatics with the veins within the substance of the glands; but the objections already urged against those observations will apply to this one also.

The lymphatic glands are inclosed in a fibrous membrane; I have in vain attempted to find the fleshy coat described by Malpighi, and which he imagined sent prolongations into the substance of these glands.

The lymphatic glands are supplied with very large arteries for their size, and they give off still larger veins: a proper tissue (*d*) appears to enter into their composition.

The lymphatic glands may be said to consist essentially of an inextricable interlacement of lymphatic vessels, their structure having some analogy to that of the corpus cavernosum penis, and to that of the spleen. This opinion is confirmed by reference to the anatomy of birds, in which lymphatic glands exist only in the neck, their place being supplied by plexuses in all other parts.

Preparation of the Lymphatic Vessels and Glands.

I have already said, that in order to inject the network of lymphatics, the pipe should be very superficially introduced into the free cutaneous, serous, or mucous surfaces. When the injection is successful the mercury passes from this network into the vessels which emerge from it, reaches as far as the lymphatic glands, and even penetrates through several series of them.

The great number and peculiar arrangement of the valves prevents the injection of the lymphatics from the centre towards the extremities: I have attempted to do this several times, without success, by introducing the tube into the thoracic duct.

From the small caliber of the lymphatics it is necessary to use a capillary tube for these injections. Mercury, notwithstanding the inconvenience of its fluidity, and incapability of being made solid, is the most convenient material for the purpose; the weight of a column of mercury, about fifteen or eighteen inches in height, affords sufficient power for the injection. Anel's syringe is well adapted for injecting the thoracic duct, which may be filled with a solution of isinglass, or still better with milk, which becomes coagulated by the alcohol. The best apparatus for injecting the lymphatics is a glass cylinder, to the lower end of which is adapted a flexible tube, which is termi-

* [Within the gland the lymphatics form a dense network (*c*); when the vessels of which this network is composed are distended, they give the cellular appearance to a section of the gland noticed by Malpighi, Cruickshank, &c.]

nated by a metal pipe, provided with a stop-cock, and supporting a capillary tube of glass, which is better than one made of steel or platinum, like those generally used in Germany. A ring is attached to the upper end of the glass tube, by means of which the apparatus may be suspended: this greatly facilitates the employment of the apparatus.

In order to inject the lymphatics, one of these vessels should be exposed at a greater or less distance from the centre: for example, in the lower extremity, upon either the internal or external malleolus, or, what is still better, over the metatarso-phalangal articulations, in the way practised by Mascagni; the vessel must then be punctured, and the tube introduced into its interior; the stop-cock is then opened, and the mercury runs as far as the gland into which the vessel opens, and at the same time enters all the vessels which anastomose either directly or indirectly with the one into which the tube is introduced. The vasa efferentia are also soon injected, and if the experiment be continued long enough, the mercury will, in all probability, reach the thoracic duct if no rupture should occur. The internal jugular, subclavian, and brachio-cephalic veins of both sides of the body may be previously injected, in order to prevent the mercury entering these vessels by the thoracic duct and its supplemental canals.

We may also have recourse to the following method, on account of its greater facility: puncture a lymphatic gland with a capillary tube; all the efferent vessels which communicate with the cells thus punctured, and all the other portions of the lymphatic system which communicate with those vessels will thus be injected. But this method is manifestly defective.

With regard to the choice of subjects it may be remarked, that the lymphatics are much more easily seen when the cellular tissue is moderately infiltrated, than when there is extreme emaciation. Fat subjects are the worst of all: adults are preferable to children and old subjects.

In describing the lymphatics, I shall follow the same arrangement as Mascagni, with some slight modifications. Thus, after having described the thoracic duct and the great right lymphatic trunk, I shall notice in succession all the lymphatic vessels which enter it, beginning with those of the lower extremities. I shall not describe the vessels and glands separately, but I shall group the vessels around the glands, as around central points towards which they all converge.

DESCRIPTION OF THE LYMPHATIC SYSTEM.

The Thoracic Duct — the right thoracic duct. — The Lymphatic System of the Lower Extremity — of the Pelvic and Lumbar regions — of the Liver — of the Stomach, Spleen, and Pancreas — of the Intestines — of the Thorax — of the Head — of the Cervical regions— of the Upper Extremity and upper part of the Trunk.

The Thoracic Duct.

Dissection. The thoracic duct may be examined, when distended with chyle, in an animal killed during the process of digestion. If it is to be injected in the human subject, turn the intestines to the left, and the liver to the right; seek for the reservoir of Pecquet (*receptaculum chyli*) between the aorta and the right crus of the diaphragm; follow one of the lymphatic trunks leading from this reservoir to the lumbar glands, and puncture it with the injecting tube. Care must be taken to tie the left subclavian vein both on the inside and on the outside of the termination of the internal jugular vein; or still better, first fill the subclavian and internal jugular veins with a solid injection. If we wish to make a preparation to be preserved, it is much better to inject the thoracic duct with isinglass size by an Anel's syringe, than to use mercury.

The *thoracic duct* (*s t t u*, *fig.* 223.), so called from its situation, is the common trunk of all the lymphatics of the human body, excepting those of the right side of the head, neck, and thorax, and of the right upper extremity.

It commences opposite the second lumbar vertebra, by the junction of a variable number of branches: Meckel says there are three, but I have generally found five or six. These vessels, which are usually of large size, pass out from the abdominal lymphatic glands: they all converge towards a dilatation or ampulla of a triangular shape, which is called the *reservoir* or *cistern of Pecquet* (cisterna, receptaculum chyli, *s*, *fig.* 223.), after the anatomist who showed that the lacteals did not pass to the liver, as was generally believed in accordance with the opinion of Aselli, but that they entered the thoracic duct.

This ampulla, which is often nothing more than the point at which the lymphatic vessels meet, and presents no dilatation, is situated to the right of and behind the aorta, immediately below the aortic opening in the diaphragm, and by the side of the right crus of that muscle.

Having commenced thus, the thoracic duct passes vertically upwards, enters the thorax through the aortic opening in the diaphragm, and becomes situated in the posterior mediastinum (*t t*), in front of the vertebral column, a little to the right of the median line, and has the vena azygos (*a a'*) on its right side, and the aorta on its left. Having reached the front of the fourth dorsal vertebra, it inclines towards the left, still continuing to ascend, passes behind the aorta, gains the left side of the œsophagus, runs along behind and on the inner side of the left subclavian artery, and escapes through the superior opening of the thorax; having arrived behind the left internal jugular vein, and in front of the seventh cervical vertebra, it immediately bends forwards, so as to form an arch (*u*) like that of the aorta, and finally opens into the angle formed by the junction of the left internal jugular and subclavian veins, or sometimes into the subclavian vein externally to that angle. The direction of the thoracic duct is not straight but flexuous: its windings are sometimes very numerous.

From the relations of the thoracic duct whilst within the posterior mediastinum, it follows, that, in order to expose its lower portion, it must be sought for on the right side of that cavity, and that we must look for its upper portion on the left side, and must divide the left layer of the mediastinum in order to expose it.

The thoracic duct terminates in many different ways: thus, it not unfrequently opens by several trunks into the left internal jugular and subclavian veins. A still more frequent method of termination, and one which it is extremely important to know, is that in which the duct at its upper part is divided into two branches, the left one of which (*u*) is distributed in the usual manner, whilst the right (indicated by a smaller letter *u*), opens into the right subclavian vein in connection with the great lymphatic duct of the right side.

The *caliber* of the thoracic duct is not at all proportioned to the number and size of the lymphatics which terminate in it. Sometimes, in fact, lymphatics are found which, when distended, are as large as a goose-quill. Still less is it proportioned to all the lymphatics of the body, of which it is regarded as the common trunk. Its caliber is even smaller than that acquired by some lymphatics under many circumstances; for example, by those of the uterus during pregnancy: this is a powerful argument in favour of those who regard the thoracic duct as by no means corresponding to all the lymphatics of the human body.

The thoracic duct is not of uniform caliber in its entire length. It commences by a dilatation of two or three lines in diameter; in the middle of the thorax it becomes contracted to less than two lines in diameter, and it is again dilated a little at the arch which it forms before its termination.

The thoracic duct not unfrequently divides during its course into several branches, which form a sort of network; it often subdivides into two branches of unequal size, which unite again after a variable distance.

The thoracic duct receives, whilst in the thorax, a very large trunk, which is derived from the liver, and perforates the diaphragm through a special opening. I have seen this trunk cross and continue in front of the thoracic duct, being equal to it in size, and at last enter it opposite the fifth dorsal vertebra.

The thoracic duct has been observed to end on the right side, and then the lymphatics of the left side of the head, left upper extremity, left lung, and left side of the heart, entered separately into the subclavian vein of the corresponding side. Meckel has correctly observed that such a disposition is a first trace of the lateral transposition of the viscera.

Valves. Of all parts of the lymphatic system the thoracic duct has the fewest and the smallest valves. The most remarkable are those situated at its termination in the subclavian vein; their free borders are turned towards the vein, so that they oppose any influx of the venous blood into the thoracic duct. The free borders of the other valves, when they exist, are turned upwards, their convex borders being directed downwards: the course of the fluid within the duct is therefore from below upwards.

The Right Thoracic Duct.

The great right lymphatic duct, or *right thoracic duct*, is a large vessel, the common trunk of all the lymphatics derived from the right half of the head and neck, the right upper extremity, the right lung, the right side of the heart, and often also of those from the right half of the diaphragm and of the liver. This trunk (*v*, *fig.* 223.), which is not more than an inch long, resembles the curved portion of the thoracic duct; it opens at the angle formed by the junction of the right internal jugular and subclavian veins.

Sometimes this common trunk does not exist, and then the lymphatics by the junction of which it is usually formed, enter the veins separately. Anastomoses always exist, moreover, between the left and right thoracic ducts.

The Lymphatic System of the Lower Extremity.

The Lymphatic Glands of the Lower Extremity.

The lymphatic glands of the lower extremity are the *anterior tibial gland*, the *popliteal gland*, and the *inguinal glands*.

The *anterior tibial gland* is situated at a variable height in front of the interosseous ligament, generally at its upper part. Hewson has seen it below the middle: Meckel has found two glands here; but the existence even of one gland is not constant.

The *popliteal glands* are four in number; one of them is situated immediately beneath the fascia; the other three are placed deeply at variable heights along the vessels of the popliteal space: they are rather small.

The *inguinal glands* are the most numerous and important; they are situated in the fold of the groin, below Poupart's ligament, and are generally grouped around the entrance of the internal saphenous into the femoral vein, in a sort of depression formed between the adductor longus and pectineus on the inside, and the psoas and iliacus on the outside. They are not unfrequently continued along the internal saphenous vein as low down as the middle of the thigh. They are divided into *superficial* and *deep*. The latter are very variable in size and number, and are often wanting: they are sometimes continuous with the superficial, through the saphenous opening in the fascia lata. The number of the superficial glands also varies much: it is nearly always inversely proportioned to the size of the glands, which is also subject to great variety in different individuals and at different ages. There can be no doubt that these differences in number and in size depend, *cæteris paribus*, no less upon actual differences than upon the subdivision of one gland into several, or rather upon the union

of a certain number of glands into one. Sometimes we find a large circular gland situated around the termination of the saphenous vein. The inguinal glands, moreover, are placed at different depths in the substance of the fibrous layers which constitute the *superficial fascia.* Several of these glands are frequently united to each other, not only by lymphatic vessels, but also by prolongations of their proper substance.

The Lymphatic Vessels which enter the Lymphatic Glands of the Lower Extremity.

Preparation. Introduce the pipe into some of the lymphatic vessels between the toes, over the metatarso-phalangal articulations. Mascagni employed this method, which is as easy as introducing the pipe into the vessels which run between the internal malleolus and the skin. A still better method of injection, when it proves successful, is to fill the lymphatic network in the skin, by introducing the pipe into the dermis at any point, beneath the cuticle. But the limb requires to be warmed for this injection to succeed. I have made a very beautiful preparation by injecting the cutaneous network of lymphatics upon the sole of the foot in a new-born infant. The mercury ran as far as the glands situated along the iliac vessels.

If the pipe be inserted into the skin upon the scrotum, or into the mucous membrane covering the glans penis in the male, or into the skin of the labia majora in the female, the mercury will reach the lymphatic glands of the groin.

The lymphatics which ramify in the gluteal region, and those situated in the subcutaneous cellular tissue of the abdominal parietes, may be injected in the same manner.

The deep lymphatics of the leg open into the anterior tibial gland and popliteal glands. All the superficial lymphatics of the lower extremity and also those of the gluteal region, perineum, external genital organs, and sub-umbilical portion of the parietes of the abdomen, terminate in the inguinal glands.

Lymphatics of the lower extremities. The lymphatics of the lower extremities, like the veins, are divided into superficial and deep.

The *deep-seated lymphatics* are fewer in number and less accurately known than the superficial; they accompany the deep-seated bloodvessels. It is probable that every arterial and venous branch has its corresponding lymphatics; but those only which accompany the great vessels have been as yet discovered. They are divided into the peroneal, the anterior and posterior tibial, and the femoral.

Of the *anterior tibial lymphatics* two only have been demonstrated, although their number must certainly be greater. One of these accompanies the plantar arch, the dorsal artery and vein of the foot, and the anterior tibial vessels; it communicates with the posterior tibial and the peroneal lymphatics, opposite the upper part of the interosseous ligament, and enters the anterior tibial gland, or more frequently perforates the interosseous ligament, and enters the popliteal glands.

The other anterior tibial lymphatic arises deeply from the outer side of the foot, and joins the preceding.

The *posterior tibial lymphatics,* two or three in number, and likewise the *peroneal* lymphatics, sometimes unite into a single trunk, and enter the popliteal glands.

The branches which emerge from the popliteal glands, five or six in number, traverse the opening in the adductor muscle, ascend along the femoral vein, and open into the deep inguinal glands.

The *superficial lymphatics,* which can be very easily shown to arise from a network in the skin, run upwards and inwards, to reach the inner side of the leg, and then pass behind the internal condyle of the femur: those which arise from the outer side of the foot and leg, after ascending vertically in front of the muscles of the anterior region of the leg, cross over the upper part of

the tibia obliquely from without inwards; so that all the superficial lymphatics at last gain the inner and back part of the internal condyle of the femur: from this point they incline forwards like the sartorius upon which they are placed, and then pass vertically upwards, and are distributed to the different lymphatic glands of the groin.

A certain number of lymphatic vessels which commence upon the outer border of the foot (there are not more than two or three), pass over the external malleolus to reach the external saphenous vein, become sub-aponeurotic like that vein, and enter the most superficial of the popliteal glands. These lymphatics which accompany the external saphenous vein, are regarded by some authors as forming part of the deep set of vessels.

Superficial lymphatics of the external genital organs, gluteal region, perineum, and lower part of the abdomen. The superficial lymphatic vessels from these parts also enter the inguinal glands.

The *superficial lymphatics* of the *external genital organs of the male* are divided into those of the scrotum and those of the penis. If the skin of the scrotum be injected, several subcutaneous branches will be seen to pass from the network beneath the epidermis upwards along the sides of the penis, and then, after describing a curve with the concavity directed downwards, to open into the inguinal glands, generally into those which are nearest the middle line, but I have seen them pass to the glands surrounding the saphenous opening. If we inject the skin of the penis, and more especially the membrane covering the glans, the mercury penetrates into the dorsal lymphatics of the penis, and reaches the innermost and highest of the inguinal glands. The injection from the skin of the penis enters the superficial lymphatics; the injection from the membrane covering the glans enters only those superficial lymphatics, which accompany the dorsal bloodvessels of the penis.

In the female, injections of the skin of the labia majora, and of the mucous membrane of the labia majora, labia minora, and clitoris, yield similar results as the injection of the scrotum and penis in the male. We know that diseases of the labia, nymphæ, and clitoris, like those of the prepuce, penis, and scrotum, occasion enlargement of the inguinal lymphatic glands.

The *lymphatics of the perineum* unite with the preceding and with the lymphatics of the lower extremities.

The *superficial lymphatics of the gluteal region* turn horizontally round the glutæus maximus and medius, and enter the external and middle lymphatic glands of the groin. This is the reason why furunculi or other diseases of the skin upon the nates may give rise to enlargement of the inguinal glands.

The *superficial lumbar lymphatics*, as well as those of the *sub-umbilical portion* of the abdominal parietes, have a descending course: those of the loins run forwards and downwards, those of the abdomen vertically downwards; they both terminate in the outermost and highest of the inguinal glands; and hence diseases of the skin covering the lumbar and sub-umbilical regions may occasion swelling of the inguinal glands.

The lymphatic vessels which accompany the epigastric and circumflex iliac veins also enter the glands of the groin.

The Lymphatic System of the Pelvic and Lumbar Regions.

The Pelvic and Lumbar Lymphatic Glands.

The lymphatic glands of the pelvis are divided into the *external iliac*, the *internal iliac*, and the *sacral*.

The *external iliac lymphatic glands*, irregular in number, are situated along the artery of that name. Three of them require to be particularly noticed; they are situated immediately behind the femoral arch, one of them on the outer side, another in front, and the third on the inner side of the external

iliac vessels. It is important, in reference to the ligature of the external iliac artery, to know that these lymphatic glands are subject to enlargement.

The *internal iliac lymphatic glands* occupy the space between the external and internal iliac vessels. The bladder has proper lymphatic glands situated upon its posterior surface, and near its summit. In the female, some of the pelvic lymphatic glands may be regarded as belonging to the vagina and uterus. One tolerably large gland, which may be said to be constant, occupies the internal orifice of the obturator canal, and I have often found it inflamed or indurated in diseases of the uterus.

The *sacral lymphatic glands* occupy the sides of the anterior surface of the sacrum: several of them are situated within the folds of the meso-rectum, and belong to the rectum itself.

The *lumbar or aortic lymphatic glands* are very numerous, and form a continuous chain with the pelvic glands; they occupy the angular interval between the common iliac arteries, being placed along those arteries themselves, and also surround the aorta and the ascending vena cava, but more particularly the aorta. It is important to note the relation of these lymphatic glands with the aorta, for that vessel is sometimes found much compressed and narrowed from enlargements of these glands by tubercular or cancerous deposit.

There is also a lymphatic gland in each inter-transverse space on both sides of the lumbar region; so that the lumbar lymphatic glands may be divided into the *median* and the *lateral*.

The Lymphatic Vessels which enter the Pelvic and Lumbar Lymphatic Glands.

The different lymphatic vessels which proceed from the inguinal glands enter the pelvis, behind the femoral arch, and near the femoral vein: the foramina through which they pass, are so numerous, that the fascia which is perforated by them is named the *cribriform fascia*. Having arrived beneath the peritoneum, they are divided into two sets, one of which descends into the cavity of the pelvis, and terminates in the several internal iliac lymphatic glands; whilst the other enters the external iliac glands, and more particularly those situated behind the femoral arch. These external iliac glands, moreover, are joined by the *epigastric lymphatics*, some of which enter the inguinal glands, and by the *ilio-lumbar lymphatics*.

The lymphatic glands of the pelvis also receive the deep lymphatics of the nates, which accompany the gluteal and sciatic arteries; the lymphatics corresponding with the obturator vessels; the lymphatics of the bladder and lower end of the rectum, those of the prostate and vesiculæ seminales, and the deep lymphatics of the penis in the male, and those of the vagina, clitoris, and neck of the uterus, in the female. The lymphatics of the bladder, before entering the pelvic glands, traverse the glands proper to itself; the greater number of the lymphatics of the bladder run beneath the peritoneum upon its posterior surface. I have seen the vesical lymphatics filled with pus. Some other lymphatics emerging from the internal iliac glands accompany the external and internal iliac arteries and veins, ascend in front of the sacrum, pass through other lymphatic glands, and arrive at the brim of the pelvis. At this point, the lymphatics of the right and left sides unite together. These vessels pass through one or several series of lumbar lymphatic glands, and at last open into the thoracic duct. This collection of lymphatic vessels and glands forms the internal and external iliac lymphatic plexuses. The internal iliac lymphatic plexus is placed in the cavity of the pelvis, and surrounds the internal iliac vessels; the external iliac lymphatic plexus is situated along the vessels of that name.

All the lymphatics of the lower extremities, after having passed through a greater or less number of glands, open at last into these lumbar glands, so that the vessels and glands together may be said to form an uninterrupted chain.

Thus, passing from plexus to plexus, and from gland to gland, the lymphatics of even the most distant parts arrive at length at the thoracic duct.

The *lateral lumbar lymphatic glands*, viz. those which occupy the spaces between the transverse processes of the lumbar vertebræ, receive the lumbar lymphatics properly so called, which correspond to the bloodvessels of that name. From these glands, communicating vessels pass to the aortic lumbar glands. The collection of lymphatic vessels and glands, occupying the lumbar region, is called the lumbar lymphatic plexus. The following lymphatic vessels also enter directly into the lumbar glands: — the lymphatics of the testicles in the male; the lymphatics of the ovaries and Fallopian tubes, and also of the body and upper part of the neck of the uterus, in the female; and the lymphatics of the kidneys in both sexes.

The lymphatics of the testicle. It has been already stated that the lymphatics of the covering of the testicle enter the superficial inguinal glands; those which belong to the gland itself are divided into the *superficial* and *deep*. The superficial lymphatics may be injected with the greatest facility, by puncturing the serous membrane covering the tunica albuginea; the tunica vaginalis will then appear as if covered with a coat of silver. (See the beautiful plates of Panizza.) These superficial vessels have numerous communications with the deep-seated lymphatics; so that both sets are injected at the same time. All the lymphatics from the epididymis and the body of the testicle, which are very numerous and large, ascend with and assist in forming the spermatic cord, pass through the inguinal canal, follow the course of the spermatic vessels, and enter the lumbar lymphatic glands.

The lymphatics of the uterus. Having in diseases of the uterus incidental to the puerperal state, frequently detected pus in the lymphatics of the uterus (vide *Anat. Path.* liv. xiii. pl. 1, 2, 3.), I have been able to trace the exact distribution of these vessels, and would divide them into *superficial* and *deep*. The superficial lymphatics are situated immediately under the peritoneum; the deep lymphatics form several successive layers, which occupy different planes within the substance of the uterus. The lymphatics near the neck of this organ enter the pelvic and sacral lymphatic glands. A certain number of the uterine lymphatics enter a lymphatic gland situated at the internal orifice of the obturator canal.

All the uterine lymphatics, excepting those near the neck of that organ, pass towards the sides and upper border of the uterus; some run within the substance of the broad ligaments, and they all reach the upper or tubal angles of the viscus. They are joined by the lymphatics of the *ovaries*, *broad ligaments*, and *Fallopian tubes*; and then ascend in front of the corresponding ovarian artery and veins. Having arrived in front of the lower part of the kidneys, they incline towards the middle line, and enter the glands which are situated in front of the vena cava and aorta. Without having witnessed it, it is impossible to form any idea of the enormous size, which the uterine lymphatics may acquire during pregnancy; several of these vessels, when filled with pus, become so dilated, that one would at first sight believe that an abscess had been formed.

The *lymphatics of the kidneys and suprarenal capsules.* These are divided into *superficial* and *deep*. The superficial lymphatics have never been injected directly; but if a fine injection be thrown into the renal arteries and veins, the injection freed from colouring matter passes into the lymphatics. This was the only way in which Mascagni could inject the superficial lymphatics of the kidney, which he has represented in his beautiful plates.

The deep lymphatics, which are very numerous, pass out of the fissure of the kidney, and enter the glands in front of and behind the aorta and vena cava.

The lymphatics of the *suprarenal capsules* are remarkable for their size and number; they unite with those of the kidneys, and terminate in the same manner.

The Lymphatic System of the Liver.

Preparation. — Of all the lymphatic vessels, those of the liver are the most easily demonstrated. Before they are injected, they may be rendered more apparent, and even be filled, by throwing water either into the hepatic arteries, the vena portæ, the hepatic veins, or the hepatic ducts. In order to inject them, it is sufficient to make a superficial puncture in any part of the peritoneum covering the liver; but it is most convenient to operate upon one of the lymphatic trunks which run upon the surface of that organ. It is of importance that the tube should be introduced between the peritoneal covering and the fibrous coat, without perforating the latter. It is sufficient to inject from a single vessel, in order to fill all the others. The mercury generally runs as far as the nearest lymphatic gland, the resistance in which causes the fluid to flow back into the surrounding branches, even as far as their most delicate ramifications, so that in successful injections the whole surface of the liver has a silvery aspect; the possibility of injecting the lymphatics of the liver, from the trunks towards the branches, must lead us to suppose that there are fewer valves in them than in the lymphatics of other parts of the body.

The Lymphatic Glands of the Liver.

These are situated along the hepatic vessels, behind the pylorus, and are continuous with the cœliac lymphatic glands. I have seen them of a jet black colour; a liquid may be expressed from them, resembling that contained in the bronchial lymphatic glands.

The Lymphatic Vessels of the Liver.

The lymphatics of the liver may be divided into the *superficial* and the *deep*.

The *superficial lymphatics.* These are subdivided into those of the convex, and those of the concave surface.

The *lymphatics of the convex surface* of the liver consist of a certain number of trunks, some of which belong to the right, and the others to the left lobe. Some of them run from behind forwards, others from before backwards towards the posterior border of the organ.

The first set, or those which run from behind forwards, reach the suspensory ligament of the liver, and unite into several trunks, some of which perforate the diaphragm, enter the anterior mediastinum, behind the xiphoid cartilage, and terminate in the mediastinal lymphatic glands; whilst others are reflected over the anterior margin of the liver, to gain the longitudinal fissure, along which they run as far as the gastro-hepatic omentum, by which they are conducted to the lymphatic glands placed round the pylorus, to those around the cardiac orifice of the stomach, and to those which lie along the lesser curvature of that organ, and near the lobulus Spigelii.

The second set of the lymphatics of the convex surface of the liver, or those which run from before backwards, having reached the posterior border of the liver, divide into three distinct groups of vessels: those on the left enter the substance of the left triangular ligament of the liver; those on the *right* pass into the right triangular ligament, whilst the remainder, which occupy the middle, enter the substance of the coronary ligament.

Those lymphatics of the second set that do not perforate the diaphragm, enter the lymphatic glands along the vena cava, and from thence reach the thoracic duct. Some of them run along the lower border of the twelfth rib, and open into the glands situated near its posterior extremity, and into another gland which rests upon the twelfth dorsal vertebra.

Those lymphatics of the second set which do perforate the diaphragm, pass through its crura, and proceed some to the intercostal lymphatic glands, or into those which lie along the vena azygos and the aorta, and thence into the

thoracic duct; whilst others enter that duct directly. I have seen a very large lymphatic trunk open directly into the thoracic duct, opposite the fifth dorsal vertebra. Mascagni pointed out some lymphatic vessels which, after having perforated the fleshy fibres of the diaphragm, ran between the pleura and that muscle, re-entered the abdomen through the aortic opening in the diaphragm, and then passed into the glands surrounding the aorta and vena cava, or entered the thoracic duct at no great distance from the reservoir of Pecquet, without passing through any lymphatic glands.

The *lymphatics of the concave surface of the liver* consist of several trunks, which are all directed from before backwards, and are divided into three sets: those which are situated to the right side of the gall-bladder; those which surround it; and those which are situated to its left side.

Those situated on the right of the gall-bladder partly enter the lumbar glands and partly terminate in the glands around the vena cava and aorta.

Those which surround the gall-bladder form a remarkable plexus, which accompanies the hepatic vessels, and terminates in the lymphatic glands which lie along those vessels, and in the glands situated in the substance of the gastro-hepatic omentum. Among this set of lymphatics, I would point out one considerable trunk, which runs in the cellular tissue connecting the gall-bladder to the liver.

The lymphatic trunks, on the left of the gall-bladder, end in the œsophageal lymphatic glands, and in those which occupy the lesser curvature of the stomach.

The deep-seated lymphatics of the liver. These vessels accompany the hepatic ducts and the vena portæ, and are contained with them in the capsule of Glisson; they emerge from the transverse fissure of the liver, penetrate the substance of the gastro-hepatic omentum, and enter the lymphatic glands situated along the lesser curvature of the stomach and behind the pancreas.

Those lymphatics of the liver which accompany the hepatic artery and duct, and the vena portæ, are extremely large, and are often filled with yellow lymph: they are sometimes found distended with gas in cases of commencing putrefaction. They were known long before the lacteals; indeed they were the first lymphatic vessels that were discovered.

The Lymphatic System of the Stomach, Spleen, and Pancreas.

The Lymphatic Glands of the Stomach, Spleen, and Pancreas.

Those of the stomach accompany the coronary vessels along the great and lesser curvatures of the stomach; some of them are situated within the gastro-splenic omentum, and a great number surround the pyloric and cardiac orifices.

The lymphatic glands of the spleen occupy the hilus of that organ.

The *pancreatic lymphatic glands* are ranged along the splenic artery, and consequently along the upper border of the pancreas; several of them are grouped around the cœliac axis. They receive a very great number of lymphatic vessels.

The Lymphatic Vessels of the Stomach, Spleen, and Pancreas.

The lymphatic vessels of the *stomach* are divided into the *superficial* and *deep.*

The *superficial* lymphatics form a network beneath the peritoneum; the deep lymphatics arise from an equally complex network situated in the mucous membrane. They follow different directions: a great number of them pass to the great curvature and enter the glands situated there; others proceed to the lesser curvature and pass through the glands in that situation. Several run towards the spleen, and enter the splenic lymphatic glands; and, lastly, others go to the lymphatic glands around the pylorus.

It has been stated that the lymphatics of the stomach have been seen filled with chyle; this is at least doubtful.

The lymphatics of the spleen. The superficial lymphatics of this organ cannot be seen unless the splenic bloodvessels have been previously injected with sise injection: the sise freed from the colouring matter will pass into them. I have seen tallow, thrown into either the arteries or veins of the spleen, pass into the superficial lymphatics. It is true that the injection was made forcibly and kept up for some time. The deep lymphatics of the spleen are not known.

The proper lymphatics of the *pancreas* are little known.

The Lymphatic System of the Intestines.

The Lymphatic Glands of the Intestines.

The *lymphatic glands of the small intestine*, or the *mesenteric glands*, are extremely numerous. Several anatomists, who have had the patience to count them, have arrived at very different results, partly on account of individual varieties, and partly because several, having chosen tuberculated subjects for the purpose, have mistaken the tubercles for lymphatic glands.

The mesenteric glands are situated between the folds of the mesentery, in the meshes of the network formed by the arteries and veins. Those which are nearest to the intestine are found in the intervals observed between the vessels of the mesentery close to the intestine. Those which are most distant from the intestine are situated near the adherent border of the mesentery, along the trunk of the superior mesenteric artery. The largest of these glands are found near the origin and termination of that artery. Thus we find, below, a group of large lymphatic glands, the *ileo-colic*, opposite the termination of the ileum in the colon. Another cluster, named the *duodenal*, is situated above, in front of the duodenum: they are extremely large. We generally find one larger than the rest: it is represented in the oldest works on anatomy, and has been sometimes mistaken for the pancreas.

The group of *ileo-colic lymphatic glands* is remarkable for frequently becoming inflamed in follicular enteritis.

The *lymphatic glands of the great intestine*, or *meso-colic glands*, much less numerous than those of the mesentery, generally lie along the vascular arches formed by the colic arteries and veins: several of them are situated near the posterior border of the intestine; and some are even found upon the intestine, accompanying those bloodvessels which run for a short distance beneath the peritoneal coat, and then penetrate the muscular coat. The meso-colic lymphatic glands are not nearly so numerous along the transverse colon as along either the ascending or descending colon. Those situated in the transverse meso-colon form an uninterrupted chain with the mesenteric glands.

The Lymphatic Vessels of the Intestines.

The lymphatics of the small intestine. These vessels are divided into two sets, the *lymphatics*, properly so called, and the *lacteals*.

The *lymphatics*, properly so called, like those of the stomach and great intestine, arise from two sets of networks — one in the serous, the other in the mucous coats. The vessels which pass out from these networks have a remarkable character, which was well described by Mascagni; instead of passing directly into the mesentery, they first proceed for a short distance along the intestine, and then curve and enter the mesenteric glands.

The *lacteals*, or *lacteal vessels of the small intestine*, can be easily seen in an animal that has been killed whilst the absorption of chyle is going on in the intestine, and they have occasionally been observed in the human subject, in cases of accidental death. They then appear as white, nodulated, and slightly

flexuous lines, which communicate occasionally with each other, pass from one mesenteric gland to another, enter the lymphatic glands situated in front of the aorta and vena cava, and terminate in the thoracic duct by a variable number of trunks: the lymphatic plexuses of the left side pass behind the aorta.

The lacteals commence, according to Lieberkühn, upon the summit of each of the villi of the small intestines, run down to its base, and then enter at right angles into the submucous lacteal vessels, which invariably perforate the other coats of the intestine, on its concave border. This arrangement was very evident in a case in which the lacteals were filled with tuberculous matter. (*Anat. Pathol.* liv. ii. pl. 2.*)

The lymphatics of the great intestine. We may with Mascagni divide these lymphatics into two sets according to the glands in which they terminate; viz. those of the cœcum, and of the ascending and transverse colon, which pass through the meso-colic lymphatic glands and then terminate in the mesenteric glands, and those of the descending colon and rectum, which enter the lumbar lymphatic glands together with the lymphatics of the genital organs and of the lower extremities.

The Lymphatic System of the Thorax.

The Lymphatic Glands of the Thorax.

The thoracic lymphatic glands are divided into those of the parietes of the thorax, those of the mediastinum, and the bronchial or pulmonary glands.

The *lymphatic glands of the parietes of the thorax* are very small, and are thus arranged: the *intercostal glands* are situated on each side of the spine near the costo-vertebral articulations; some are placed between the two layers of the intercostal muscles: they are very small, and irregular in number. The *substernal* or *mammary glands* are found at the anterior extremity of the intercostal spaces near the internal mammary vessels, and applied along the borders of the sternum; there is one for each intercostal space.

The *mediastinal lymphatic glands* are divided into *those of the posterior mediastinum*, which are arranged along the œsophagus and aorta, and form a continuation of the intercostal glands: they have been known to become enlarged and press upon the œsophagus, so as to cause dysphagia; and into those *of the anterior mediastinum*, the principal of which lie upon the diaphragm in front of the pericardium, and around the great vessels connected with the base of the heart.

The *bronchial or pulmonary glands* were noticed by the oldest anatomists and especially by Vesalius, whence the name of *glandulæ Vesalianæ*, by which they are still known: they are remarkable for their situation, number, size, and colour. They are situated along the bronchi and their first divisions. The largest are generally placed opposite the bifurcation of the trachea. The smallest lie within the substance of the lungs, around the first divisions of the bronchi; some of them are seen in the interlobular fissures.

Their number is very considerable.

In disease, they may acquire such a size as to compress and narrow the bronchi, and thus prevent the passage of the air through those tubes.

In infancy they do not differ in colour from the other lymphatic glands, but they are black in the adult, and especially in the aged. They are also liable to become the seat of depositions of phosphate of lime.

Senac considers them to be secreting glands quite distinct from the lymphatic glands. Portal divided them into true glands and lymphatic glands; but no one has been able to demonstrate the excretory ducts, which, according to Portal, proceed from the lymphatic glands upon the trachea. The communications between these and the trachea, observed in some cases of disease, are altogether accidental.

* See also note, Vol. I. p. 487.

The Lymphatic Vessels of the Thorax.

The lymphatic vessels of the thorax are divided into those of the parietes and those of the organs contained in the thoracic cavity.

The lymphatics of the thoracic parietes. We shall here merely notice the deep-seated lymphatics. They are divided into the intercostal, the substernal or internal mammary, and the diaphragmatic.

The *intercostal lymphatics* accompany the arteries and veins of that name; they receive the lymphatic vessels of the intercostal muscles and costal pleura, run along the grooves of the ribs, pass through the intercostal lymphatic glands, reach the sides of the vertebræ, unite with other lymphatics from the back of the thorax and from the spinal canal, enter the lymphatic glands on the sides of the vertebral column, and are for the most part directed downwards to terminate in the thoracic duct.

The *substernal* or *internal mammary lymphatics* arise from the supra-umbilical portion of the anterior walls of the abdomen; they pass into the thorax, behind the ensiform cartilage, and form two bundles, which run upon the sides of the sternum, unite with the anterior intercostal and external mammary lymphatics, and enter the internal mammary lymphatic glands. From the lowest of these glands other lymphatics proceed, and ascend in succession from one gland to another up to the inferior cervical lymphatic glands; on the left side they enter the thoracic duct, and on the right, the great lymphatic trunk. Sometimes, but rarely, the mammary lymphatics open directly into the internal jugular and subclavian veins.

The *lymphatics of the diaphragm* for the most part unite with the intercostal and hepatic lymphatics; the others run forwards between the pleura and the fleshy fibres of the diaphragm; some of them enter the inferior mediastinal glands, and the others, the internal mammary lymphatic glands.

The lymphatics of the thoracic viscera. The *lymphatics of the lungs* are divided into superficial and deep: the *superficial* lymphatics may be injected in the same manner as those of the liver; they form an extremely close network beneath the pleura pulmonalis, and frequently present a number of, as it were, varicose enlargements: these were noticed and figured by Mascagni; and the frequency of their occurrence led him to inquire whether such was not the natural structure of lymphatics. Some of the vessels which proceed from this network run in the interlobular fissures, and enter the lymphatic glands situated at the bottom of these fissures; whilst the others reach the internal surface of the lung, and terminate in the bronchial glands.

These superficial lymphatics also communicate with the deep lymphatics, in the cellular intervals between the lobules of the lung.

The *deep lymphatics of the lung* are very numerous: the manner in which they commence in the lobules is not well known: they run in the interlobular cellular tissue, and all proceed towards the root of the lung, in order to terminate in the glands situated around the bronchi, and in several which lie along the œsophagus. It is doubtful whether a single pulmonary lymphatic vessel enters directly into another lymphatic gland, without first going through a bronchial gland.

Other lymphatics proceed from these bronchial glands; some of which pass in front of the trachea to enter the tracheal lymphatic glands, whilst the others proceed to the lymphatic glands upon the œsophagus. On the left side both sets enter the thoracic duct, at a short distance before its termination; these are more numerous than those on the right side, which enter the right lymphatic duct. Some of them terminate in the thoracic duct, before it emerges from the thorax; several of these vessels are also seen to enter the internal jugular and subclavian veins.

I should observe that, in consequence of the above mentioned anatomical

fact, the cervical lymphatic glands sometimes become enlarged in diseases of the lungs.

The lymphatics of the heart, pericardium, and thymus. The *lymphatics of the heart* are divided into superficial and deep; the *superficial* vessels commence by a subserous network, and for the most part run along the right border of that organ; the *deep* lymphatics arise from the internal membrane of the heart, in which I have never been able to inject a perfect network: they all accompany the coronary vessels, and all pass out of the pericardium; some of them unite with the lymphatics of the lung; the others enter the glands in front of the arch of the aorta and pulmonary artery, and from thence pass to the thoracic duct.

The *lymphatics of the pericardium and thymus* enter the internal mammary, anterior mediastinal, and bronchial lymphatic glands.

The Lymphatic System of the Head.

The Lymphatic Glands of the Head.

There are more lymphatic glands in the *face* than in the *cranium.*

All the *lymphatic glands of the cranium* are found upon its posterior region: some of them are situated behind the ear along the attachments of the occipito-frontalis; several are placed beneath the upper end of the sterno-mastoid; they are very small, and often escape notice in a hasty dissection: they become very distinct in diseases of the scalp.

Are there *any deep lymphatics of the cranium?* The pituitary body, the pineal gland, and the white bodies known as the glandulæ Pacchioni have been regarded as belonging to the lymphatic system. Some authors have even considered the tubercles, so frequently found in the brains of infants, and which are evidently accidental formations, to be of the same nature. Certain bodies found in the carotid canal, and which are evidently enlargements of the ganglionic nerves, have also been described as lymphatic glands: but this opinion is now completely rejected.

Of the *lymphatic glands of the face*, the largest occupy the base of the lower jaw, and are called the *sub-maxillary* lymphatic glands: several of them are situated upon the outer surface of the maxillary bone, along the facial vessels, in front of the masseter muscle.

We find also in the face, the *parotid lymphatic* glands, some of which are superficial and others deep, the latter being situated in the substance of the gland: we find some also between this gland and the masseter: lastly, there are the *zygomatic* glands, situated under the zygoma, and the *buccinator* lymphatic glands.

The Lymphatic Vessels of the Head.

These belong either to the *cranium* or to the *face.*

The lymphatics of the cranium. The *superficial* or *subcutaneous cranial* lymphatics are divided into two sets; the *temporal lymphatics*, which run along the superficial temporal artery, and pass through the parotid lymphatic glands, from which vessels proceed to the glands in the anterior region of the neck; and the *occipital lymphatics*, which follow the occipital artery, and terminate in the mastoid and the occipital lymphatic glands.

The *deep lymphatics of the cranium*, the *lymphatics of the dura mater*, or the *meningeal lymphatics*, accompany the meningeal vessels, escape through the foramen spinale of the sphenoid bone, and enter the jugular lymphatic glands.

Ruysch appears to have been the first who noticed lymphatics in the brain; he has named them *vasa pseudo-lymphatica.* Mascagni could only show the presence of the superficial lymphatics of the brain by injecting coloured sise into the carotid arteries. The sise freed from the colouring material passed into the lymphatics.

The lymphatics of the brain are but little known. M. Fohmann has described and figured a lymphatic plexus situated between the arachnoid and pia mater, and precisely resembling those found in other parts of the body: This network dips into the sulci, and appears to be continued into the substance of the brain, where it is no longer possible to follow it. From this network some small lymphatic trunks proceed, and accompany the arteries and veins as far as the foramina, in the base of the cranium, beyond which M. Fohmann was never able to trace them; so that he inquires whether these vessels do not form an exception to the general rule from their want of connection with the absorbent system generally, and whether they do not enter directly with the veins upon which they are placed. On the other hand, Mascagni has figured some lymphatics around the internal carotid, within the carotid canal, and also around the vertebral arteries and internal jugular vein. The existence of these trunks leads us to suppose that there must be cerebral lymphatics.

M. Fohmann has also found lymphatics in the choroid plexuses of the lateral ventricles of the brain: these vessels were remarkably dilated, so as to present ampullæ.

The lymphatic vessels of the face. These are divided into the superficial and deep.

The *superficial lymphatics* are much more numerous than those of the cranium. They commence upon all parts of the face; those from the frontal region accompany the frontal vessels: the others accompany the adjacent bloodvessels; several of them pass through the buccinator glands, and they all finally enter the sub-maxillary lymphatic glands. The lymphatics of the face are to be injected by introducing the pipe into the plexus contained in the skin.

The *deep lymphatics of the face* accompany the bloodvessels. They are divided into those of the temporal fossæ, those of the zygomatic and pterygo-maxillary fossæ, and those of the nasal fossæ. The lymphatics of the pharynx, velum palati, mouth, tongue, and larynx, enter the deep parotid and the cervical lymphatic glands. The lymphatic plexuses of the pituitary membrane and of the lingual, buccal, and pharyngeal mucous membranes may be perfectly injected. Indeed, it is only in that way that we can demonstrate the lymphatic vessels which emerge from these different parts.

The Lymphatic System of the Cervical Regions.

The Cervical Lymphatic Glands.

The lymphatic glands of the neck are concentrated in the anterior region of the neck. They are divided into the *superficial* and *deep.*

The *superficial lymphatic glands* of the neck are found principally along the external jugular vein; they are therefore situated between the platysma and the sterno-mastoid; and in the supra-clavicular triangle, that is to say, in the triangular interval between the clavicle, the sterno-mastoid, and the trapezius. We also find several very small superficial glands, between the os hyoides and the thyroid cartilage, and upon the sides of the larynx.

The *deep lymphatic glands* of the neck are very numerous, and form an uninterrupted chain around the internal jugular vein and the carotid artery, from the mastoid process to the superior opening of the thorax, in front of the vertebral column, and upon the sides of the pharynx and œsophagus.

The *tracheal lymphatic glands* are also continuous with the deep cervical glands.

The cervical glands form a continued series with the facial and sub-maxillary lymphatic glands on the one hand, and with the lymphatic glands of the thorax and axilla on the other.

The Cervical Lymphatic Vessels.

The *cervical lymphatics* consist of those which have passed through the sub-maxillary and facial lymphatic glands, and which afterwards traverse the chain

of glands along the jugular veins. They are joined by those of the pharynx, œsophagus, larynx, trachea, and thyroid gland. They then proceed from one lymphatic gland to another, and from one plexus to another down to the lower part of the neck, where they are joined by some lymphatics from the lung, which also pass through some of the cervical glands: they terminate on the left side in the thoracic duct, and on the right side in the right lymphatic duct.

The Lymphatic System of the Upper Extremity.

The Lymphatic Glands of the Upper Extremity, and of the Upper Part of the Trunk.

There are generally no lymphatic glands in the hand or forearm, but Meckel found several very small ones along the ulnar and radial bloodvessels. There are two or three which are subcutaneous in the front of the bend of the elbow, and one or two above the internal condyle of the humerus behind the basilic vein; in the arm we also find a series of small lymphatic glands, which are never numerous, along the inner side of the humeral artery.

The *axillary lymphatic glands* are situated deeply in the axilla, and are very numerous; some lie along the great vessels, others are scattered through the axilla: they are often of a very large size.

The following may be regarded as appendages of the axillary glands, a small sub-clavicular lymphatic gland, situated deeply beneath the costo-coracoid membrane, opposite the triangular interval between the pectoralis major and the deltoid, and two or three small glands situated along the attachments of the pectoralis major, as far as the mammary gland.

Mascagni has figured a small lymphatic gland near the umbilicus.

The Lymphatic Vessels of the Upper Extremity and of the Upper Half of the Trunk.

The lymphatics of the upper extremity. The *superficial* set of these vessels arise from the skin of the hand, and run parallel to the fingers: they are for the most part situated upon the back of the hand; they cross obliquely over the metacarpal bones, pass over the carpus, and thus reach the forearm.

In the *forearm* they are distributed almost equally upon its anterior and posterior aspects.

The anterior lymphatics are collected upon the inner and outer sides of the forearm; having reached the elbow, some pass in front of the epitrochlea and its muscles; others in front of the epicondyle. In this place they are reinforced by the lymphatics from the posterior aspect of the forearm, which are also collected into an outer and inner group. Not unfrequently a certain number of the posterior lymphatics, which arise from the outer side of the hand and forearm, after ascending almost vertically for some distance, pass obliquely, or cross transversely inwards, above and below the olecranon, and unite with the inner group.

In the *arm* some of the inner group of lymphatics pass to the lymphatic glands above the epitrochlea; the others run along the inner border of the biceps muscle and basilic vein, and then pass backwards and upwards to reach the axillary glands.

The external lymphatics cross very obliquely over the anterior aspect of the arm, to terminate, like the preceding, in the axillary glands. One of them has a remarkable course; it runs along the cephalic vein, gains the cellular interval between the pectoralis major and the deltoid, dips down over the upper edge of the pectoralis minor and below the costo-coracoid membrane, and describes a curve so as to enter the sub-clavicular lymphatic ganglion.

The *deep lymphatics* of the upper extremity exactly follow the course of the bloodvessels; they often communicate with the superficial lymphatics,

and terminate in the axillary glands. I have seen some of the deep lymphatics of the forearm communicate at the bend of the elbow with the superficial lymphatics on the outer part of the back of the arm, and enter the glands above the epitrochlea.

The lymphatic vessels of the upper half of the trunk. We have seen that all the lymphatics of the sub-umbilical portion of the trunk enter the inguinal glands; and so all the lymphatic vessels of the supra-umbilical portion terminate in the axilla.

The *anterior and lateral lymphatics* pass upwards upon the pectoralis major and the serratus magnus, to gain the axilla.

The *posterior lymphatics* are divided into those of the neck and those of the back; the *posterior cervical lymphatics* descend upon the trapezius and the deltoid, and are reflected over the posterior border of the last-named muscle, in order to reach the cavity of the axilla; the *posterior dorsal lymphatics* run in different directions, some horizontally, the others from below upwards to be reflected into the axilla below the tendons of the latissimus dorsi and teres major.

NEUROLOGY.

Neurology is that part of Anatomy which treats of the apparatus of sensation and innervation: this apparatus consists of the *organs of the senses*, of the *cerebro-spinal axis*, or central portion of the nervous system, and of the *nerves*, or peripheral portion of that system.

THE ORGANS OF THE SENSES.

The Skin — its external characters, structure, and appendages. — The Tongue considered as the Organ of Taste. — The Organ of Smell — the nose — the pituitary membrane. — The Organ of Sight — the eyebrows — the eyelids — the muscles of the orbit — the lachrymal apparatus — the globe of the eye, its membranes and humors — the vessels and nerves of the eye. — The Organ of Hearing — the external ear — the middle ear or tympanum — the internal ear or labyrinth — the nerves and vessels of the ear.

The *organs of the senses* are certain parts of our bodies, which are intended, by means of the sensibility they possess, to establish relations between us and external objects. The organs of the senses, to use a strong figurative expression, are, as it were, the bridges which connect the individual with the world around him. (*Meckel's Anatomy*, by Jourdan, p. 471.)

The organs of the senses, being placed between the brain and surrounding objects, have the following characters in common: they occupy the surface of the body; they communicate with the brain by means of nerves of greater or less size; and, lastly, each of them has a peculiar structure in harmony with that particular quality of matter, the perception of which it is intended to convey to us.

Anatomists generally admit five organs of sense, which we shall name and then describe in the following order:— the *skin*, or the organ of tact and touch, the *organ of taste*, the *organ of smell*, the *organ of sight*, and the *organ of hearing*.

The Skin.

General Remarks on the Skin.

The *skin*, the proper organ of tact and of touch, is a membrane which serves as a covering or integument to the body, and is so accurately moulded upon it, as to preserve the form, and yet conceal the inequalities, of its entire surface. It may be regarded as forming an external surface or limit, endowed at the same time with *sensibility* and a *power of resistance;* enabling us by the one to perceive such qualities of bodies as are distinguishable by the touch, and by the other preserving us, to a certain extent, from their action. It forms, moreover, an exhalant surface, or sudorific organ, by which the system is freed from noxious substances, and also an inhalant surface, by which fluids may be absorbed.*

* Some ancient authors, Marcus Aurelius Severinus among others, adhering closely to the order of super-imposition, which is sometimes called the anatomical order, commenced the description of the human body with the skin; and the same part, though for a very different reason, is described first by M. de Blainville in his *Anatomie Comparée*: that celebrated naturalist, carrying out analogical induction to its utmost limits, makes the skin the fundamental organ of the body, connecting with it all the organs of the senses, which he regards as analogous to hairs, and names *phaneræ* (a word constructed by M. Blainville in opposition to the term *cryptæ*, hidden, and derived from φανερος, evident, manifest, apparent). He considers that the apparatus of locomotion is a developement of the elastic element of the skin, which becomes endowed with contractility; the digestive and respiratory organs he regards as modifications of the absorbent apparatus of the skin; and the organs of secretion and generation as developements of its exhalant structure. The circulatory apparatus alone is not derived by him immediately from the external integuments; yet he almost believes that it is an extension or prolongation of the meshes of the cutaneous cellular tissue.

External Characters.

Examined in reference to its external characters, the skin presents an *external* or *free* surface, and an *internal* or *adherent* surface.

The free surface. Upon the *free surface* of the skin the following objects require attention: its folds, or wrinkles, and its furrows; a peculiar colour, which is subject to variety in different races of men, and in different individuals; certain horny growths, as the nails and hairs, which are appendages of the skin; and, lastly, numerous orifices for the escape of the cutaneous secretions, some of them being the orifices of the sebaceous follicles, others of the sudorific glands, whilst others again are the foramina, or depressions through which the hairs protrude. The horny growths of the skin will be noticed presently; and its colour and orifices, or pores, will be examined under the head of its structure.

We shall here make a few remarks upon the different folds or wrinkles found in the surface of the skin: they are of several kinds.

Some of them may be termed *folds of locomotion;* they are permanent, and are inherent, as it were, in the skin itself, and have distinct relations to the various movements of the body. They are of two kinds; the *larger folds* are observed around the joints, both on the aspect of flexion, and that of extension: for example, over the knuckles, and in the palms of the hands; the *small folds* are found over the whole surface of the skin, which is divided by them into irregular lozenge-shaped intervals: it is to these folds that the skin owes its extensibility.

Other folds, called wrinkles, are produced by the contraction of subcutaneous muscles: such as the transverse wrinkles produced by the action of the occipito-frontalis, the vertical wrinkles by that of the corrugatores supercilii, and the radiated folds caused by the contractions of the orbicularis palpebrarum, the orbicularis oris, and the sphincter ani. These wrinkles, like the contraction of the muscles by which they are produced, are only transitory; but they become permanent when their causes are frequently repeated. In the same class as these we must include the corrugations of the skin of the scrotum, from contraction of the dartos.

The folds or wrinkles resulting from *age* and from *emaciation* depend upon the skin becoming, after more or less distension, too much stretched, and, therefore, too loose to fit closely to the parts beneath. Hence, emaciation in young subjects does not produce the same effects as in the aged; for in the latter, the wrinkles are caused by the want of elasticity in the skin, and they are more distinct in proportion as that property is lost. In cases of extreme distension, when the skin has been altered in its texture, the wrinkles are more marked and are permanent: as, for example, those observed on the abdomen of females after pregnancy, and of either sex after dropsy.

Furrows between the papillæ. It is necessary carefully to distinguish from the folds or wrinkles of the skin those more or less regular but slight furrows which exist between the linear ridges or eminences formed by the cutaneous papillæ in the palm of the hand and the sole of the foot, and which are also found, though in a less marked degree, in all other parts of the body.

Adherent surface of the skin. In mammiferous animals the skin is lined throughout the greater part of its extent by a layer of muscular fibres, which are intended to act upon it, and constitute the cutaneous muscle or *panniculus carnosus;* but in man the only traces of this structure are the platysma myoides and the palmaris brevis.

The subcutaneous muscles of the human subject are concentrated in the face. It follows, therefore, that, although in animals the passions can be expressed by movements of the entire surface of the body, in man their expression is limited to the face. It has been erroneously supposed that the phenomenon termed *cutis anserina,* or *goose-skin,* a corrugated condition of the

skin, in which the bulbs of the hairs are rendered prominent by being forced outwards, depends upon the contraction of a layer of muscular fibres situated beneath the integument. But the most careful examination has demonstrated no muscular fibres there: we do not even find a dartoid tissue, such as is observed wherever there exists a certain kind of active contractility independent of the will.

Beneath the skin of the human subject we find a layer of adipose tissue, *panniculus adiposus;* it varies in thickness, and is contained in the meshes formed by the fibrous lamellæ, which extend from the internal surface of the skin, and are then either attached to the investing aponeuroses where the skin is said to be adherent, or become expanded into a very thin aponeurotic membrane, called the *fascia superficialis*, in which case the skin is movable. The quantity of subcutaneous adipose tissue, and the fixed or movable condition of the skin, have a constant and necessary relation with the functions of each particular region. Thus, whilst adipose tissue is very abundant in the palm of the hand and sole of the foot, where we always find a *cushion* of fat, it is never present in the skin of the eyelids and penis.

When the skin over any bony eminence is required to be very movable, and at the same time is exposed to continual friction, we find beneath it a sort of synovial capsule, or *bursa* as it is called: some of these bursæ exist at birth, and belong to the original organisation; whilst others are accidental, and result from friction.

We must regard the subcutaneous adipose tissue as a dependence, or even as a constituent part, of the integument, for it is impossible to separate one completely from the other. The adipose tissue, in fact, penetrates into, and entirely fills, the areolar spaces in the skin.

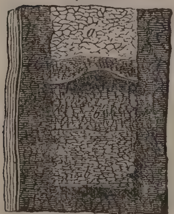
The cutaneous vessels enter or pass out, and the cutaneous nerves penetrate at the adherent surface of the skin, and more particularly opposite the areolæ observed on that surface: so that whenever the skin is stripped off for a certain extent, it either sloughs off, or its vitality is so greatly impaired as to be incapable of completing the process of cicatrisation. An accurate idea is, perhaps, not generally entertained of the enormous quantity of nervous filaments and of the immense number of arteries which enter the skin, or of the number of veins which issue from it. Its importance, both in a healthy and in a diseased condition, is sufficiently explained by these anatomical facts regarding it.

Structure of the Skin.

The skin consists essentially of the *cutis*, *dermis*, or true skin (*a*, *fig.* 226.); of the *papillæ*, which project upon its external surface; of the *pigmentum*, or colouring matter (*b'*); of the *lymphatic network*; and of the *epidermis*, or cuticle (*b*): as accessory parts it also contains the *sebaceous follicles*, as well as *arteries*, *veins*, *lymphatics*, *and nerves*; and has connected to it the hairs and the nails.

The cutis or chorion. The *dermis*, *chorion*, or *cutis vera* (*a*, *fig.* 226.; *e*, *fig.* 227.) is the fundamental part or the basis of the skin; and to it the skin owes its strength, extensibility, and elasticity. If the skin be regarded as formed of several distinct layers, the dermis constitutes the deepest of these.

Fig. 226.



Skin of Negro.

The *thickness* of the dermis varies in different parts, but is always in proportion to the amount of resistance which it is required to offer. Thus, in the cranium, it is very thick and dense; on the face generally it is thinner than on the cranium, but not in every part of the face. Compare, for example, its density and thickness in the skin upon the lips with its tenuity and delicacy in that of the eyelids. On the trunk it is almost twice as thick behind as in front; and upon the penis, scrotum, and mamma it is much thinner and finer than upon any other part

of the anterior aspect of the body. In the limbs the dermis is much thinner on the surfaces which are turned towards the median line and on the aspect of flexion, than it is on the outer side of the limbs and on the aspect of extension, which are more exposed to the action of external objects. On the palms of the hands and soles of the feet, which are almost incessantly in contact with external objects, the dermis is very thick.

The thickness of the dermis varies in different individuals, and also according to sex and age. In old persons it participates in the general atrophy of the tissues, and becomes so thin as to be somewhat translucent, and enables us in certain regions to distinguish beneath it the pearly aspect of the tendons, and the reddish colour of the muscles.

The dermis has a *deep surface* and an *epidermic* or *papillary surface.*

The deep surface presents a number of conical depressions, the base of each of which corresponds to the subcutaneous layer of adipose tissue, whilst its summit is directed towards the outer surface of the skin, and is pierced with very fine openings. These depressions or alveoli, which are most strongly developed in the soles of the feet and palms of the hands, are filled with conical prolongations or masses of fat, which when inflamed give rise to boils, and in a state of gangrene constitute the slough from such sores.

When examined in reference to its structure, the dermis is found to be composed of bundles of cellulo-fibrous tissue, interlaced with each other, and becoming closer and closer towards its external surface: this fibrous tissue is scarcely extensible or elastic, so that the extensibility and elasticity of the skin are due, not to the nature of the dermoid tissue, but to the arrangement of its component bundles.* The elasticity of a tissue may depend, like that of caoutchouc, upon the nature of its material, or, like that of a spiral piece of brass wire, may result from the arrangement of that material. The elasticity of the skin appears to be of the latter kind.

The papillæ. Upon the external or epidermic surface of the cutis are found a multitude of small eminences, which are either arranged side by side, in rows or ridges (*d*, *fig.* 227.), as in the palms of the hands and soles of the feet, or are irregularly scattered over the surface. These eminences are called the *cutaneous papillæ*; together, they constitute the *papillary body* (*corpus papillare*). To understand them properly we must examine a section of a portion of skin from the palm of the hand or sole of the foot; which section should be made transversely to the direction of the papillary ridges (see *fig.* 227.): numerous small eminences are then seen projecting from the dermis into the substance of the epidermis, which may be distinguished from these projections by its transparency and its horny appearance. The papillæ are still more distinctly seen by removing the epidermis from a piece of skin, and then examining the latter under a thin layer of fluid.

The papillæ consist of a spongy erectile tissue † containing nervous filaments, arteries, and veins.

The nerves of the papillæ are very numerous. In reference to this point it is observed, that the number of nervous filaments distributed to the skin is always in a direct ratio with the number and size of the cutaneous papillæ: and hence the nerves of the skin covering the palm of the hand are exceedingly numerous.

Several anatomists state that they have seen the nerves spreading out like pencils in the papillæ themselves. ‡

* The dermoid, like other cellular and fibrous tissues, is resolved into gelatine by boiling. It acquires great density and strength in the process of tanning, by which it is converted into leather.

† It is impossible to doubt the analogy of the papillæ of the skin to those of the tongue, and even to the intestinal villi. Although we are unacquainted with their precise structure, it is enough to know that they are composed of an erectile spongy tissue, in which both nerves and vessels terminate. The nervous filaments can be traced by dissection as far as the bottom of the alveolar depressions in the dermis.

‡ Analysis of a former Memoir upon the Structure and Functions of the Skin, by MM. Breschet and Roussel de Vauzème. These authors state that they have ascertained that the

The papillæ receive both arteries and veins; in successful injections with mercury, or with glue-size, spirit-varnish or turpentine, coloured with vermilion, all the papillæ are penetrated by the injection, and exhibit, both in their interior and on their surface, a vascular network, which might be called an erectile tissue.*

Lymphatics of the skin. If we introduce the pipe of the mercurial injecting apparatus very obliquely beneath the epidermis, the mercury, if the process is successful, will run into a *sub-epidermic network* of vessels, and will soon cover the skin with a metallic layer. These vessels are most evidently lymphatics, for the mercury soon passes from them into the subcutaneous lymphatic vessels, and from them into the adjacent lymphatic glands: in no case does it enter the bloodvessels.

Mascagni, who has given so many representations of the vessels of the skin in his beautiful plates, has delineated in several of them this lymphatic network, lying superficially to the layer of bloodvessels.

The universal prejudice against microscopical observations had very improperly thrown some discredit upon the positive results obtained by this great anatomist, when an accidentally successful injection enabled Haase to trace and delineate the cutaneous lymphatics of the groin from the skin to the inguinal glands. † M. Lauth also by accident injected the lymphatic network of the same region. Panizza in 1830 clearly demonstrated the arrangement of the superficial lymphatic network upon the glans penis and the prepuce, in his beautiful injections of that organ in the human subject and in animals. Lastly, M. Fohmann (*Essai sur les Vaisseaux Lymphatiques de divers Ordres* 1833) has made some special researches upon this subject, viz. upon the lymphatic network in the skin and in other parts. Two beautiful plates, one representing the skin of the mamma, and the other that of the scrotum, glans penis, and prepuce, give a perfect idea of the arrangement of this network, which, when filled with mercury, forms a silvery layer beneath the epidermis. From this network branches are given off which perforate the dermis in all directions, and enter the subcutaneous lymphatic vessels proceeding from its internal surface. We have succeeded perfectly in injecting the subcutaneous lymphatic vessels in the entire lower extremity of a new-born infant, merely by introducing the pipe into the sole of the foot.

This lymphatic network is remarkable for being situated superficially to the bloodvessels, as Mascagni had correctly observed, and for being completely independent of any other system of vessels; also, for its vessels being dilated into ampullæ at various places, for being destitute of valves, and for not opening any where upon the surface of the skin; so that, excepting from laceration, the mercury does not escape through the pores of the epidermis. Lastly, the network generally consists of two very distinct layers situated between the epidermis and the dermis; one extremely delicate and superficial, the other lying immediately upon the dermis and belonging to deeper vessels. ‡

The pigmentum. All the different shades of colour observed in the skin of the several races of mankind belong to either the white, the black, or the cop-

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nerves of the skin terminate in loops or arches, as had been pointed out by MM. Prevost and Dumas, in regard to the nerves of the muscles. We shall elsewhere see what is to be thought concerning the existence of these terminal loops of the nerves in muscles, and the theory of muscular contraction founded upon it.

* [The papillæ are prolongations of the vascular and nervous chorion.]

† De Vasis Cutis et Intestinorum Absorbentibus. Lipsiæ, 1789. In the plate given in this work the lymphatic plexus is very badly represented.]

‡ According to M. Fohmann, the skin is composed of the following parts proceeding from within outwards: — 1. The panniculus adiposus. 2. The internal layer of the dermis characterised by its fibrous meshes. 3. A vascular layer composed of lymphatics, and the terminations of the bloodvessels and veins, united by a small quantity of animal matter. 4. A vascular network, formed exclusively by the ultimate ramifications of the lymphatics. 5. The rete mucosum of Malpighi. 6. The epidermis.

per coloured variety: they depend upon the presence of a colouring matter, called the *pigmentum*, which exists in the European as well as in the negro, though in a less marked degree, and which is deposited beneath the epidermis.

This colouring matter, or *pigmentum* (*b′*, *fig.* 226.; *c*, *fig.* 227.), may be demonstrated in the skin of the negro (represented in *fig.* 226.) with the greatest facility by means of maceration. It is then found not to be contained in special vessels as Bichat supposed, but to be deposited beneath the epidermis, where it constitutes an uniform layer, that either comes off with the epidermis, or remains attached to the dermis, but is independent of either.* The epidermis, the papillæ, and the chorion are of precisely the same colour in the negro as in the white races. The pigmentum of the skin is identical in every respect with the choroid pigment in the eye, and is formed of black molecules insoluble in water. Blumenbach conjectured that this black matter was nothing more than carbon: several experiments appeared to confirm this opinion, but it is now generally believed to be formed by the colouring matter of the blood.* In the European it escapes observation, because it does not differ much in colour from the epidermis and dermis.

The colour of the skin, which is a matter of such interest in the natural history of mankind, and which forms one of the principal characters of the several human races, has a tolerably constant relation to the colour of the hair: thus, individuals with light hair have generally fairer skins than such as have dark hair; and thus, also, red hair is accompanied with a somewhat analogous colour of the skin. In albinos the colouring matter is deficient in the skin, as it is in the hair, and in the interior of the eye. Moreover, the transition, in regard to the colour of the skin, from the white to the black races of mankind occurs through a succession of intermediate shades: thus, I have found a colouring matter precisely similar to that of the negro's skin beneath the epidermis of several Europeans, particularly upon the scrotum, and upon the tanned faces of those who have lived exposed to a strong solar heat. In the disease called black or green jaundice, the skin of white persons becomes black or olive coloured. A superficial chronic irritation produced by blisters, or certain skin diseases, or by an adjacent wound, will also sometimes cause a black discoloration of the skin.

As to the source of the pigment of the skin, it is thought by M. Gauthier that it is yielded by the bulbs of the hairs. M. Breschet describes a series of glandular organs for secreting this pigment, which, according to him, are situated in deep furrows in the outer portion of the dermis, and are surmounted by a great number of excretory tubes, from which the globules of pigment are poured out beneath the epidermis. I have never been fortunate enough to ascertain the existence of these glandular organs and their excretory tubes. It is generally supposed, that the vessels of the cutaneous papillæ are the source whence the pigment is derived; the mechanism of its formation must be the same as that of the formation of the choroid pigment in the eye, and it is quite as little understood.*

The epidermis. The epidermis, or cuticle (*b*, *fig.* 226.; *a b*, *fig.* 227.), is the outermost of the several layers of the skin; it is a semi-transparent, horny layer which is moulded upon the surface of the dermis and its papillæ like a coat of varnish, and protects them from the action of external agents. Its internal surface is in fact marked by a multitude of little pits, into each of which a papilla is received; so that this surface of the epidermis may be said to form a mould of the papillary surface of the skin. In the skin of the negro, the colouring matter occupies the little pits in the epidermis, and is found in greater abundance between the papillæ than upon them.

In order to obtain a good view of the structure of the internal surface of the epidermis, various sections may be made of the skin upon the palms of the hands and soles of the feet. It will then be seen that the papillæ dip, as it

* See note, p. 844.

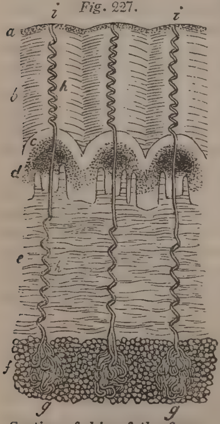
were, into the epidermis, which furnishes a kind of sheath for each of them. This arrangement is exceedingly distinct in the skin upon the lower surface of the bear's foot. I have alluded to this structure in my *Anatomie Pathologique* ("Diseases of the Lymphatics," liv. ii.). M. Breschet has recently observed it in the skin of the whale, in which animal the epidermis forms a complete tube for each of the papillæ. These sheaths, or tubes, are united by a glutinous matter, and may be separated, at least in the bear, with the greatest facility.

The internal surface of the epidermis is intimately adherent to the external surface of the dermis; but this adhesion may be destroyed in the living subject by the application of a blister, and after death by maceration. If in a piece of macerated skin the epidermis be carefully separated from the true skin, it will be seen that the adhesion of one to the other is in part effected by a number of very delicate transparent filaments, which may be stretched to the extent of several lines without breaking. On examining the internal surface of the epidermis under water, these filaments are seen floated out.

What then is their nature? Are we to regard them with Cruickshank as prolongations of the epidermis which dip into the areolæ of the true skin? or, with Beclard, as strings of mucus formed by the stretching out of the viscid mucous matter situated between the dermis and the epidermis? or, on the other hand, are they canals? and if so, Are they to be regarded as exhalant vessels, as Kaaw Boerhaave, and W. Hunter believed? are they exhalant and absorbent vessels too, as Chaussier and Bichat imagined? or are they not rather special vessels, the *vasa sudoris* of Bidloo, and the *vasa sudatoria* of Eichorn, the latter of whom attributed to them both an exhalant and an absorbent function? These questions are not yet satisfactorily solved. The very great activity, both of exhalation and absorption by the skin, necessarily supposes the existence of some special apparatus for these processes.

Steno, Malpighi, and others, admitted the existence of certain *sudoriferous glands*, situated in the adipose cellular tissue, and consisting of tubes which opened on the exterior by means of an orifice provided with a valve. (Vide *Haller*, t. v. lib. xii. p. 42.) This description, when somewhat modified, agrees with the statements recently made by M. Breschet, who has described sudoriferous glands (*g g*, *figs.* 227, 228.) having a saccular form, and situated in the substance of the dermis. A spiral canal* (*h*, *fig.* 227.) proceeding from each of these sacs, traverses the dermis and epidermis, and after having made several turns, opens upon the external surface of the skin (at *i*).†

Fig. 227.



Section of skin of the finger, magnified 14 times.

Besides these filaments the deep surface of the epidermis presents certain irregularities, which may be felt by the finger, and which under the microscope appear pointed like thorns; they seem to be prolongations of the epidermis, but I have not been able to determine their precise nature.

The *external surface* of the epidermis presents corresponding folds and furrows to those already described upon the free surface of the skin. It also has numerous orifices or pores, visible to the naked eye on the palms of the hands and soles of the feet, and very distinctly seen by the aid of a lens. Along each of the ridges formed by the rows of papillæ are found a series of orifices, arranged in a re-

* Fontana had previously spoken of serpentine vessels, which he had seen beneath the epidermis by means of the microscope.

† [The sudoriferous glands, discovered by Breschet, Purkinjè, and Wendt, may be seen best by examining under the microscope a thin perpendicular section of a piece of skin taken from the

gular manner, and resembling in appearance the puncta lachrymalia in the eyelids. If the skin be examined with a lens during life, whilst the person is perspiring, drops of the excreted fluid are seen to exude, and form into a small globule, which is soon lost by evaporation, and after a few seconds another globule makes its appearance. It is impossible to conceive how several celebrated anatomists could have denied the existence of pores in the skin.*

Della Torre, Fontana, and Mascagni believed that the epidermis was organised, and that it consisted of a network of lymphatic vessels. But as Panizza has clearly proved (*Osservazioni Antropo-zootomico Fisiologiche*, 1830, p. 83.), the lymphatic network always lies beneath the epidermis, which may, by maceration, be raised up from it. After the example of Panizza I have endeavoured to inject the epidermis upon the soles of the feet and upon other parts of the body, but without being able to find a single vessel. As for the opinion that the epidermis contains arterial and venous capillaries, it is so at variance with the results of observation, that it does not require refutation. The epidermis, then, is unorganised [non-vascular].

It is a product of secretion, a layer of concrete, transparent, and very hygrometric mucus; a sort of horny matter, of variable thickness, capable of reproduction after having been destroyed, and the morbid alterations of which result, not from any proper vital action in itself, but from a diseased condition of those living parts of the skin by which it seems to be produced.

As to the structure of the epidermis, it has been repeatedly stated to consist of imbricated scales; but the most careful examination discloses nothing more than a layer of uniform structure, into which the papillæ enter; so that it may be decomposed, hypothetically and even actually, by the aid of the scalpel, in some animals, into a number of agglutinated tubes or sheaths, each of which belongs to a single papilla. The different forms of the fragments of epidermis, detached either spontaneously or in consequence of disease, depend upon accidental circumstances, and show the continuity of this membrane in the human subject.† I shall presently describe the relations of the epidermis to the hair, the nails, and the sebaceous follicles.

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palm of the hand (as in *fig.* 227.), and hardened in a solution of carbonate of potash. They are situated in the subcutaneous adipose cellular tissue (*f*); they consist of a long convoluted tube (or of two tubes which unite together), ending in an efferent duct (*h*), which opens (*i*) upon the free surface of the epidermis, and is lined by flattened epidermic corpuscules. Where the epidermis is thin, these ducts are nearly straight, as in the scalp (see *fig.* 228.), and their orifices are scattered irregularly over the surface; where it is thick, they have a spiral course, as in the palm and sole (*fig.* 227.), where their orifices are arranged in single rows on the papillary ridges. These spiral ducts are turned in opposite directions on the right and left extremities; the average number of their orifices is fifty in the square line, the filaments described in the text as connecting the epidermis to the dermis are the epidermic linings drawn out of these ducts, and out of the sebaceous and piliferous follicles.]

* See note, p. 842.

† [The epidermic portion of the skin has been so long supposed to consist of several distinct structures, that it is still convenient to describe separately an epidermis, a pigmentum, and a rete mucosum; but modern research has shown, that these are merely different layers of the same structure, in different stages of developement. The most superficial and hardest of these layers, which is separated from the skin in vesication during life, and by maceration after death, is the epidermis described in the text, and by authors generally; the deeper, more recently formed, and softer portions, which may be displayed and subdivided into several layers by maceration and dissection, constitute the pigmentum and the rete mucosum: together, these insensible, extra-vascular, but not inorganic layers, form what is now called the *epidermis*.

Thus defined, the epidermis exactly resembles the epithelium of mucous membranes, in consisting of a number of adherent nucleated corpuscules each of which undergoes an independent developement. Immediately upon the surface of the true skin, these corpuscules are soft roundish vesicles, containing a distinct nucleus and peculiar pigment granules, and adhering together by a viscid matter, the cytoblastema, in which they are first developed. In approaching the surface of the cuticle they become larger and more compressed, their walls become thicker and denser, their nuclei less distinct, and their pigment paler, until at length they form the thin, flattened, horny, nucleated, colourless discs, which, adhering to each other firmly in an imbricated manner, constitute the upper and horny portion of the epidermis, from the free surface of which they are constantly being thrown off as minute scales, to be continu-

According to M. Breschet, certain minute reddish glands are situated among the subcutaneous adipose vesicles, and constitute the secreting apparatus of the epidermis. Excretory ducts are said by him to proceed from the summits of these small glands, to traverse the dermis, and to open at the bottom of the furrows found upon its external surface. According to the same observer, these ducts generally resemble rows of regularly arranged columns; and the glands are sometimes situated at unequal depths from the surface, and communicate with each other by intermediate ducts. I have never succeeded in verifying these observations; and I have equally failed in attempting to decompose the epidermis into a series of layers, becoming less and less compact in proportion to their distance from the surface.

The corpus mucosum, or corpus reticulare of Malpighi. Malpighi applied the term *reticulum*, and others following that great anatomist have given the names *corpus reticulare*, *corpus mucosum*, and *rete mucosum*, to a gelatiniform layer (*d*, *fig.* 227.) of what is regarded as a concrete mucus, situated beneath the epidermis, and perforated by the papillæ, which thus gave it a reticulated appearance. This inorganic [non-vascular] layer, which Malpighi first demonstrated beneath the thick epithelium of the tongue of the ox, after it had been boiled, and which he then supposed to exist also in the skin, cannot be demonstrated anatomically; so that the expressions, *corpus mucosum*, *corpus reticulare*, have lost their original signification, and have been interpreted in a different sense. Haller, and several anatomists quoted by him, regarded the corpus mucosum as a deep layer of the epidermis, some of them confounding it with the pigmentum, and others distinguishing it from that body. Bichat considered the corpus mucosum to be an extremely delicate network of vessels, or system of capillaries, which formed, with the papillæ, an intermediate layer between the chorion and epidermis, and was partly intended to convey the blood, and partly the colouring matter of the skin.

M. Gauthier, in examining the skin of the heel in the negro, recognised four distinct layers in the corpus mucosum, arranged in the following manner, from within outwards: — 1. vascular processes containing red blood (*bourgeons sanguins*), which are situated upon and adhere to the papillæ; 2. a deep white layer, composed of serous vessels, and moulded upon the vascular processes and papillæ; 3. a layer of gemmules, forming a kind of coloured membrane, excavated upon its deep surface, and separated from the vascular processes and papillæ by the deep white layer; 4. a superficial white layer, which he regards as formed of serous vessels, as well as the deep white layer. Externally to this is the epidermis. M. Dutrochet, founding his opinion upon the examination of the skins of quadrupeds, admits the different layers of M. Gauthier, excepting the vascular processes, which he very properly regards as forming parts of the papillæ: he calls the deep white layer of M. Gauthier the *epidermic membrane*, the gemmules he terms the *coloured layer*, and the superficial white layer he names the *horny layer*.

Lastly, Gall regarded the corpus mucosum as a layer of grey nervous matter, precisely similar to that of the grey substance of the brain and of the nervous ganglia.

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ally replaced by others having a similar origin, and undergoing the same changes: these imbricated scales were described by Leuwenhoek and Baker.

The epidermis is insoluble, even in boiling water; but it swells, and becomes softened and transparent, in these respects resembling mucus and epithelium; it consists of a substance called *keratin*.

The pigment granules contained in the deeper epidermic corpuscules are the cause of the colour in the skin; they are black in the negro, &c. of lighter hues in other dark races, and fawn coloured in the European; in all cases they are darkest in the deeper and newly formed corpuscules, and fade as these approach the surface: in albinos they are either absent or colourless. The pigment contains iron and carbon, both in a combined state, phosphate of lime, and animal matter; but as it is bleached by chlorine, it contains no free carbon, as supposed by some.]

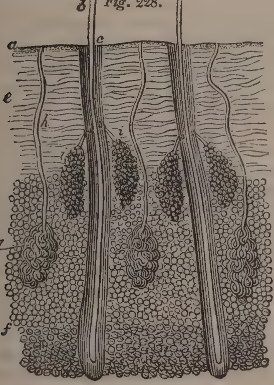
I agree with Chaussier that we ought altogether to reject the corpus mucosum, in whatever sense that term may be understood; and I believe there are good grounds for supposing that the different layers described as forming this body belong, in reality, some to the papillæ, and others to the epidermis.*

Appendages of the Skin.

Under this title may be included the sebaceous follicles and the horny growths, viz. the nails and hairs.

The sebaceous follicles. The skin contains within its substance certain *sebaceous follicles* (*i i*, *fig.* 228.); these consist of small pouches, or bags, about the size of a millet seed, which form projections beneath the epidermis, but are lodged in the substance of the dermis, and open externally by very small orifices, which are visible under a lens, and, in some persons, even to the naked eye. From these orifices an unctuous matter is constantly poured out upon the surface of the skin, and assists in preserving its pliability; in some individuals this unctuous matter may be expressed from the follicles upon the alæ of the nose, in masses which look like small worms. These sebaceous follicles are somewhat analogous to the follicles of the mucous membranes; they are not found in the palms of the hands and soles of the feet; but, in all probability, they exist in every part of the body: they are especially observed in the axilla, on the hairy scalp, and around the margins of the anus and vulva, and the openings of the nose and mouth: they are very much developed in the new-born infant. The sebaceous follicles appear to me to have a glandular structure; and this is particularly evident in those of the axilla, the organisation of which seems to me to be more complex than that of those found in other parts. The supposition that these follicles are formed by the reflection of a thin portion of the skin is altogether fanciful.†

Fig. 228.



Section of skin from the head, magnified 14 times.

The nails and the hair. In man the horny growths of the skin are less developed than in any animal exposed to similar atmospheric conditions; and in man also we find the highest developement of the sense of touch.

The *nails* of the human subject are hard, yet flexible and elastic, semi-transparent scales, and present the appearance of laminæ of horn: they are situated upon the dorsal surface of the last phalanges, which are therefore called the ungual phalanges; and they appear rather to be intended for the support and protection of the pulpy extremities of the fingers, than as weapons of attack, or instruments of defence and prehension. In a state of civilisation it is customary, therefore, to cut off that part of the nail which projects beyond the end of the finger. The ingenuity of man enables him to provide himself with offensive weapons amply sufficient to compensate for the weakness of those provided by nature, which, indeed, are quite rudimentary in him, and

* See note, p. 843.

† [The sebaceous glands (*i i*, *fig.* 228.) are multilocular follicles; their ducts are lined by epidermic corpuscules, and open upon the surface of the skin in parts without hairs; where hairs exist, they open into the hair follicles (*c*), to each of which two sebaceous glands (*i i*) are generally attached. On the face, very minute hairs have been found around the orifices of the ducts of these glands: their secretion is albuminous as well as fatty.]

if more fully developed, would greatly interfere with the delicacy of his sense of touch.

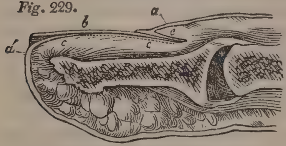
The peculiarity of the human nail consists in its only covering the dorsal surface of the last phalanx, and in its being of considerable breadth, corresponding, in this respect, with the horseshoe-like enlargement at the end of the phalanx. It follows from this, that the whole of the pulp of the finger is concerned in the exercise of the sense of touch.*

The nail is divided into the *root*, the *body*, and the *free portion*: the *root* is that part of the nail which is covered on both surfaces; the *body* is that part which has one surface free; whilst the third, or entirely *free* portion, projects beyond the end of the finger, and has a tendency to become incurvated when left to grow naturally.

In order to obtain a correct idea of the anatomy of the nails we should, by a longitudinal incision, make a vertical section of the ungual portion of one of the fingers (see *fig.* 229.). We shall then perceive that the root is about one fourth of the length of the body of the nail (*b*); that it is also the thinnest part of the nail; that it diminishes in thickness towards its posterior edge, which is slightly indented, and that it increases towards the body of the nail; that it is flexible, and is received into a duplicature of the skin (*c c*), to which it is attached by both surfaces; that the posterior edge and lower surface of the root adhere so slightly to the skin, that they may be said to be merely applied to it; that the upper surface of the root, though it adheres more closely to the skin than the lower surface, is yet much less firmly attached to it than the under surface of the body of the nail, which cannot be torn off without great violence; that the nail is separated from the phalanx by a very thick dermis (*c′*); that this skin is of a white colour at the root of the nail, and for some distance in front of it, where it occasions a semilunar white mark, visible through the transparent nail, and called the *lunule* (*lunula*); and, lastly, that the dermis, which corresponds to the body of the nail, is extremely vascular, and hence the nail has a rosy hue, because its semi-transparency enables us to perceive the colour of the subjacent tissue.

One of the most important points in the anatomy of the nail is the nature of its connection with the dermis. The fold of the skin, which is called the matrix of the nail, is formed in the following manner: — the skin (*c*, *fig.* 229., being the dermis) is prolonged from the finger on to the dorsal surface of the nail, as far as the curved line that marks the posterior boundary of the *body* of the nail; from thence it is reflected backwards, folded upon itself, as far as the posterior border of the root of the nail. At this point it is again reflected forwards upon itself by passing behind that border, and then (*c′ c′*) between the under surface of the nail and the dorsal aspect of the phalanx: in consequence of this twofold reflection it follows, that it is always the epidermic surface of the true skin that is in contact with the nail: at the anterior extremity of the nail the skin again meets, as it were, the epidermis (*a′*), and becomes continuous with the integument upon the tip of the finger. But what is the arrangement of the epidermis, at the point where the skin is first reflected backwards? It is prolonged forwards (*a*), slightly beyond the curved line formed by the reflection of the dermis, and forms a semicircular

Fig. 229.



Section of skin of hand.

* The *hoof*, of which a very perfect example is met with in the horse, is nothing more than a nail which encloses the united phalanges on all sides, like the wooden shoes sometimes worn; the *claw* of carnivorous animals is a nail which covers two thirds of the slender ungual phalanx, is compressed at the sides, and terminates in a pointed hook. The nail, properly so called, is found only in man and in quadrumana, and in the latter it approaches in character to the claw. The division of mammalia into ungulated and unguiculated is exceedingly natural, and is, in some measure, represented by certain correlative and constant differences in all the other parts of the system. (See *Anatomie Comparée de M. de Blainville.*)

zone or band, which terminates by a smooth border, and adheres intimately to the nail. As to its arrangement beyond this point authors are not agreed. Some are of opinion that it would be prolonged upon the free surface of the nail, if it were not destroyed by friction; but they overlook an objection to this view to be derived from the accustomed regularity of the epidermic border; others, again, believe that the epidermis is reflected backwards like the dermis, but differ amongst themselves as to its ultimate disposition; some for example conceiving, with Bichat, that the epidermis is continuous with the posterior border of the nail, and some supposing that it is again reflected forwards beneath the nail, together with the dermis (see dotted line), which, according to this hypothesis, it never quits.*

A very simple experiment most clearly demonstrates the nature of the connection between the epidermis and the nail: it consists in submitting a finger to the process of maceration, by means of which the nail and epidermis come off together in the form of a partly epidermic and partly horny sheath. In this the epidermis (a) is found to be reflected backwards upon the dorsal surface of the root of the nail, and to become blended with it (see *fig.* 229.), without ever passing beyond its posterior border; whilst, in front, at the limits between the body and the free portion of the nail, the epidermis (a') is manifestly continuous with the deepest layer of the horny lamina; so that it cannot be doubted that there is an identity of nature between the nail and epidermis.

Structure and growth of the nail. On examining the two surfaces of the nail, and especially its deep surface and posterior border, it is found that they are marked by very distinct longitudinal lines or striæ, which appear to indicate a corresponding linear texture. It would seem, accordingly, that the nail was formed by the agglutination into laminæ of a number of longitudinal fibres; but if we examine the free surface of the nail attentively, we find that it is marked by curved striæ, which intersect the longitudinal ones. These curved striæ are particularly distinct in the not uncommon cases in which the nail of the great toe is much hypertrophied, and becomes incurvated upon the plantar surface of the toe: the enlarged nail is found to consist of imbricated laminæ, received one into the other like the several laminæ in the hoof of an animal. We may even separate these different layers by aid of maceration, and find that they are fitted one into the other, the deepest being that which was last secreted. The nails, therefore, are developed by a method very analogous to that by which we have already stated the teeth are formed. (See Vol. I. p. 238.)

The nails, then, like the hoofs of animals, and like the epidermis, are products of secretion: they receive neither vessels nor nerves: alterations in their texture are not dependent upon diseases inherent in themselves, but result from some morbid condition of their formative organ. The fold of the dermis, which is called the matrix of the nail, is not the only part by which the substance of the nail is secreted, but the whole papillary surface of the dermis, to which the nail adheres, is concerned in its formation. The papillæ are arranged in longitudinal rows, and hence the substance of the nail is deposited in longitudinal striæ.†

The nail grows continually in length; it does not increase sensibly in thickness, excepting during disease. The layers that have been deposited the longest time are the most superficial, and occupy the free extremity of the nail, in precisely the same manner as the oldest-formed ivory in the tooth is nearest to the enamel.‡

* See note ‡, below.

† The arrangement of the papillary dermoid layer which covers the dorsal surface of the ungual phalanx, is worthy of notice: it adheres intimately to the periosteum, and forms an extremely dense, greyish stratum, penetrated by vessels and nerves; so that, if the mode of termination of the nerves in the papillæ can ever be ascertained, it is, without doubt, beneath the nail, where these papillæ present their highest state of developement.

‡ [The nails are found by Schwann to consist of nucleated corpuscules, which, like those of the epidermis, are formed upon the surface of the dermis, where they are soft and vesicular,

The hairs. The *hairs* are filiform productions of the epidermis, generally flexible, variable in length, size, and colour, and bearing different names according to the region on which they are situated.*

The surface of the human body, with the exception of the palms of the hands and the soles of the feet, is covered by very fine and short hairs, which form a light *down*, as it is named; but the hairs, properly so called, are collected upon particular parts of the surface of the body, where they serve some special purpose. Thus, they exist in great abundance upon the cranium, where they are called *the hair;* on the face, where they form the *whiskers* and *beard;* the hairs upon the margins of the eyelids are called the *eyelashes;* the arched row over each orbit is called the *eyebrow;* the hairs upon the lips constitute the *moustache.*

On the trunk the hairs are collected, in more or less abundance, around the genital organs: they exist, also, in the axillæ of both sexes; and on the chest, between the breasts, in the male. The hairs present well-marked differences according to sex, age, and the peculiar race to which the individual belongs. The pilous system is most developed in the Caucasian race, and least so in the negro.

The hair, eyelashes, and eyebrows exist before birth: before birth, also, the whole body is clothed with a very thick down, which is shed during the first few months afterwards. At the period of puberty, hairs are developed upon the pubic region and in the axillæ of both sexes, upon the labia majora of the female, and upon the scrotum and around the anal orifice in the male: the beard also appears in the male, and the anterior aspect of the trunk, and the limbs, are covered with hairs of variable length in different persons. I should observe that the developement of the hairs is not always in proportion to the personal strength, as is asserted by certain authors, who regard an abundance of hair as an attribute of strength and virility. But, although some men with hairy skins have robust constitutions, a great number are delicate, and are even affected with tubercular phthisis.

In mammalia the hairs upon the posterior or *dorsal* region of the trunk are more developed than those upon the anterior or abdominal aspect, a proof that they are destined to the quadruped attitude: in some animals, which turn upon their backs to protect themselves, the hairs upon the abdominal surface are most highly developed.

The hair of the head may grow to a very considerable length: it has been seen to reach as low down as the middle of the leg, and when thrown around the trunk, sufficiently abundant to cover it like a garment. The length and the direction of the hair upon the head evidently prove that man is destined for the erect posture; for if he assumed the attitude of a quadruped, it would trail upon the ground, and fall over the face.

The hair also presents peculiarities, or differences, in many respects; for example, in *direction*, some hair being long and smooth, some crisped and woolly; this latter kind is peculiar to the negro race, and it never grows to a very great length: also in *diameter*, some hair being excessively fine, and some large and coarse. † It differs again as to quantity, for, in general, the

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and afterwards become hard, flattened, and firmly agglutinated together, as in the substance of the nail. These corpuscules are developed, not only opposite the matrix of the nail, but beneath the whole of its attached surface; the nail is thus elongated, and at the same time its thickness is maintained, notwithstanding the flattening of the corpuscules formed at the root as they approach the surface. The thin layer of epidermis, described by Weber, Lauth, and Gurlt, as continued under the whole attached surface of the nail, is nothing more than the soft stratum of growing corpuscules, which pass insensibly into those of the true epidermis.

Like the epidermis, the nails consist of keratin.]

* The *spines* of the hedgehog, the *bristles* of the boar, the *hair* of horses, the *wool* of sheep, and the *fur* of most mammalia, are different kinds of hair.

† [The hair of the head also varies in its *form;* a section being a more or less flattened oval, or even reniform, from the hair being excavated along one side. On the face, the hairs are still more flattened.]

hair of the head is more abundant in the female than in the male, as if the activity of the pilous system was principally confined to the hairy scalp in the former sex; and, lastly, in its colour, from which certain very important distinctions among men are established.

Every different shade in the colour of the hair may be referred to three principal varieties, the *black*, the *flaxen*, and the *red*. The *flaxen* hair belongs particularly to the inhabitants of the north, and to persons of lymphatic and sanguineous temperaments; the *black* is characteristic of the inhabitants of the south, and of those of a bilious and sanguineous temperament; the *red* belongs to no particular temperament; and in our ideas of beauty, this coloured hair, which is usually accompanied with a disagreeable odour of the perspiration, is regarded as a natural misfortune.

The *beard* and whiskers are peculiar to the male sex; they occupy the lower part of the face, and consequently leave uncovered all those parts which are principally concerned in giving expression to the physiognomy, viz. the ocular, nasal, and frontal regions. We cannot insist too strongly on the connection existing between the developement of the genital organs and that of the beard. The eunuch is almost destitute of that appendage.

The great attention rendered necessary by wearing a long beard and long hair has lead to the custom of cutting the hair and shaving. It is remarkable that the most effeminate nations, the orientals for example, are those among whom long beards are in highest estimation. The influence of these different customs upon the health are deservedly subjects of examination for those who study Hygiene.

Structure and growth of hairs. The only method of obtaining an accurate knowledge of the structure of hairs is to study their growth. The extremity of the hair which is inserted into the skin is contained in a sort of *follicle*, very analogous to the dental follicles. This *hair-follicle* (*e*, *fig.* 230.), which is the formative organ of the hair, is embedded in the subcutaneous cellular tissue (*g*), and is prolonged to the surface of the skin by a sort of membranous canal, which was well described by Bichat. The *hair-follicles* consist essentially of a *pouch* or *sac*, and a *papilla*.

Fig. 230.

Magnified.

The membranous *pouch* or sac (*c c*), called the bursal membrane by Heusinger, forms a sort of cul-de-sac, having a narrow neck, and opening externally by a contracted orifice through which the hair (*b*) passes without adhering to it at all. Its walls are sufficiently transparent to allow the hair contained in its cavity to be seen. If this cavity or sac, which, according to M. Dutrochet, is formed merely by the inversion of a portion of the skin, be laid open, its internal surface (*e*) is found to be smooth, not adherent to the hair, but separated from it by a reddish liquid, first pointed out by Heusinger.

From the bottom of this sac, *i. e.* from the part furthest from the orifice through which the hair protrudes, a *papilla* (*a*), called the pulp of the hair, arises: this papilla is of a conical form, its base being adherent whilst its apex is free; it reaches nearly to the orifice of the sac, and even projects beyond it in the disease called plica polonica. Bloodvessels and nerves pass to the bottom of the hair-follicle, and are probably distributed upon the papilla.

It is upon the papilla that the hair is formed. At its commencement it resembles a *conical horny sheath*, which is exactly moulded upon the apex of the papilla. On the inner side of this horny cone another is formed, which raises up the preceding one, and so on in succession, the entire hair constantly maintaining a conical form. According to the experiments of Heusinger, who plucked out at intervals the hairs from the whiskers of a dog, and afterwards killed the animal, so as to observe the successive changes

which took place in the hair-follicles, during the developement of the new hairs, a rather long period elapses before the hair projects beyond the epidermis; but when once it has overcome that obstruction, its growth proceeds rapidly.

What is the arrangement of the epidermis at the point where the hair emerges beyond its surface? According to some it is prolonged upon the hair, and forms its outer coat; according to others, it dips into the cavity of the hair-follicle, and is reflected upon the base of the hair, so as to form upon it an epidermic tube, which falls off in scales as the hair is prolonged outwards; according to others, again, the epidermis has no connection with the hair; and I am the more inclined to subscribe to such an opinion, because the hair is of the same size both before and after it has left the follicle.*

The hair is the product of a secretion, and therefore destitute of vitality, being formed by a series of small horny cones fitted one into the other. It is generally admitted that it is composed of a horny, colourless, transparent epidermoid sheath, containing a sort of coloured pith in its interior. Bichat presumed that this central substance was formed of certain bloodvessels which contained the colouring matter; but the mode in which the hair is developed proves that it is not tubular, and, also, that the colouring matter itself is produced by the papilla at the same time as the epidermoid sheath. The white hairs of old people are merely deprived of colouring matter.†

The Organ of Taste.

The structure of the *tongue*, the organ of taste, which has already been described (see Vol. I. p. 441.), presents a greater analogy to that of the skin than any other of the organs of the senses.

The sense of taste resides essentially in the papillary membrane which covers the upper surface of the tongue.‡ It has already been stated, that the perforated eminences found at the base of the tongue are not papillæ, but glands; and the true papillæ have been divided into the large or caliciform papillæ, which are arranged in the shape of the letter V at the base of the tongue, and the small papillæ; which may be again subdivided into the conical, the filiform, and the lenticular or fungiform, according to their respective shapes.

Every special sense, by which term is understood all such as receive sensations different from that of touch, properly so called, presents for our consideration a *special apparatus*, on which the impressions act, and a *special nerve* or nerves, adapted to receive those impressions, and transmit them to the brain.

The muscular structure of the tongue, which at first sight appears to be useful only in mastication, deglutition, and the articulation of sounds, is intimately connected with the sense of taste, which would have been exceedingly imperfect had not the gustatory membrane been capable of being moved over the bodies to be tasted. The gustatory apparatus of the tongue consists, then, of a *papillary membrane* stretched over a muscular surface, and united so closely

* [The root of some hairs is larger than the shaft, and is named the *bulb;* this, however, does not depend on the hair being covered by the epidermis, a thin layer of which (*d d, fig.* 230.) lines the follicles, and is believed to terminate at the root of the hair. Into each hair-follicle one or more sebaceous glands (*i i, fig.* 227.) pour their secretion.]

† [Hairs, like the nails, consist, according to recent researches, of nucleated corpuscules, which differ in form, density, and arrangement, in different parts of the hair. At the root, upon the surface of the papilla, where they are first developed, they are soft and vesicular; in the central medullary part of the shaft they are harder, compressed, and polyedral; in the cortical part they form an immense number of very long and fine fibres, and, on the outside of these, a layer of short hard scales.

The hairs consist principally of keratin and an oily matter; besides which, they yield sulphur, phosphorus, iron, salts of lime, and traces of manganese, silica, and magnesia.]

‡ [The mucous membrane on the under surface of the tongue, and that covering the buccal surface of the soft palate and the immediately adjacent parts of the fauces, also possess the sense of taste.]

to it that it is impossible to separate one from the other. Moreover, this membrane is constantly kept in a state of humidity, and occupies the first cavity presented by the digestive apparatus.

The gustatory papillary membrane. All the elements of the skin are found in the gustatory membrane.

The *chorion* is as dense as the densest part of the chorion of the skin: a very great number of muscular fibres are inserted into it, so that the gustatory membrane can be moved not only as a whole, but each part of it has its own separate movements.

The *papillæ*, by which the surface of the tongue is rendered so rough, may be said to represent the papillary body of the skin in a very highly developed state.*

The lingual papillæ are supplied with nerves, which can be more easily shown than those in the cutaneous papillæ. Haller has traced them into the papillæ; and I have succeeded in doing the same, but without being able to ascertain their mode of termination.

The papillæ also receive *bloodvessels*, which are so abundant, that, in successful injections, the papillary body appears to be altogether vascular.

The lymphatic network. By making a superficial puncture into any part of the membrane which covers the dorsum or the borders of the tongue, we may inject a lymphatic network upon it, precisely similar to that found in the skin.

The mucous body, or *rete mucosum*, does not exist as a distinct membrane upon the tongue any more than in the skin. I have already stated that it was whilst examining the boiled tongue of the ox that Malpighi discovered a glutinous stratum situated between the epidermis and the papillæ, and perforated by a number of openings, corresponding to that of the papillæ themselves; hence the name of *reticulum* which he gave it†; but it is as impossible to demonstrate it upon the tongue as in the skin.

The pigmentum. There is never any black colouring matter in the tongue of the human subject: but it is distinct upon the tongue of some animals, as the ox, and can be easily demonstrated between the papillæ and the epithelium.‡

The epithelium. Each papilla is covered with a sort of epidermic sheath, which, according to Haller, was discovered by Mery and Cowper, and which has been perfectly described by Albinus under the name of the *periglottis*. This epidermis, or epithelium, so easy of demonstration in the lower animals, in which it has the consistence of horn, may be also readily shown in the human subject, although, in accordance with the greater perfection of the sense of taste in man, the epithelium is comparatively thin. If the upper surface of the tongue be examined with a lens, especially after maceration, the lingual epithelium will be seen to be arranged in precisely the same manner as the epidermis of the skin, and to form a protecting sheath for each papilla. In persons who have sunk after long abstinence, the epithelial covering forms several imbricated layers, which can be rubbed off: the fur which adheres to the tongue is in a great measure formed by this débris of the epithelium somewhat dried. The epithelium of the tongue can be removed by friction; and in certain inflammatory diseases the tongue is denuded of it. When one of the lingual papillæ is thus exposed, it becomes excessively painful.

* If the epidermic tubes, which are so remarkably distinct on the foot of the bear, be removed from the papillæ, the latter, when exposed, exactly resemble those of the tongue.

† "Hanc fabricam a Malpighio inventam, et a Bellino libenter acceptam, scriptores anatomicorum, et physiologicorum operum iconibus etiam pictis expresserunt." (*Haller*, t. v. lib. xiii. p. 107.)

‡ [The pigment in these cases, and the lingual rete mucosum also, are the lowermost layers of the extra-vascular squamous epithelium.]

The nerves of the tongue. No other organ, perhaps, of equal size, receives so many nerves as the tongue: one pair, the *ninth* or *hypoglossal*, is exclusively appropriated to it; and it also receives on each side the *glosso-pharyngeal* branch of the eighth, and the *lingual* branch of the fifth of the cerebral nerves. Which of these nerves must be regarded as the nerve of taste in the tongue? Evidently the one that is distributed to the papillæ. On this account, since the time of Galen, the lingual branch of the fifth pair, or the lingual nerve as it is called, has been regarded as the gustatory nerve; though it would seem more natural to admit with Boërhaave, that the hypoglossal nerve, which is distributed exclusively to the tongue, should, as it were, preside over the special sense situated in this organ. But the lingual nerve is found to enter the tongue at its corresponding border, and to spread out into branches which pass vertically upwards, and are exclusively distributed to the papillary membrane of the anterior, or free portion of the tongue.

The *ninth* or *hypoglossal nerve* of each side runs from behind forwards, between the genio-glossus and stylo-glossus muscles, and communicates with the lingual nerve, so as to form the *lingual plexus.* It is not certain that some of the filaments of the hypoglossal nerve do not reach the papillæ; but there is no doubt but that almost all of them are lost in the intrinsic muscles of the tongue.

The *right* and *left glosso-pharyngeal nerves* supply the base of the tongue, and are exclusively distributed to the mucous membrane covering that part. No filament of the glosso-pharyngeal nerve is intended for the muscular fibres; and it is a remarkable fact, that in one case in which the facial nerve sent a branch to the tongue supplementary to the glosso-pharyngeal, that branch was distributed precisely in the same manner as the glosso-pharyngeal itself; that is, it was exclusively distributed to the mucous membrane at the base of the tongue. From what is stated above, then, it is anatomically shown that the lingual branch of the fifth nerve and the glosso-pharyngeal nerve are the special nerves of the tongue.*

The following case is no less demonstrative of the same fact: — An individual had complete paralysis of the right half of the tongue. That side of the tongue became atrophied, and had scarcely one third of its natural thickness. Both its tactile and gustative sensibility were equally acute on the two sides of the organ. After the death of the person thus afflicted, an acephalocyst was found in the right posterior condyloid foramen, which had caused a complete atrophy of the right hypoglossal nerve. The corresponding half of the tongue had undergone the fatty degeneration.

The Organ of Smell.

The *organ of smell* is situated in a cavity formed within the bones of the face, as, indeed, are most of the other senses; it is placed at the entrance of the respiratory passages, and above the organ of taste, with which it has many points of relation. Although situated in the median line, it is a double organ. It consists of an external apparatus, which serves to protect the organ, to keep it in the necessary state of moisture for the proper exercise of its functions, and to direct the air towards that part of it which is endowed with the greatest olfactory sensibility: this is the *nose* properly so called.

And, secondly, of two complicated and winding cavities, the *nasal fossæ*, lined by a mucous membrane, called the *pituitary membrane*, which is the essential seat of the sense of smell.

* [The result of the vast number of experiments and observations made upon this subject by persons of opposite opinions would appear to be, that the lingual nerve (a branch of the fifth), and the lingual portion of the glosso-pharyngeal nerves, are both of them gustatory nerves, and also nerves of ordinary sensibility to the tongue. The portion of the palate and fauces endowed with the sense of taste derives its power from the palatine nerves, which are given off from a ganglion (Meckel's) connected with the second division of the fifth nerve.]

The Nose.

The *nose* resembles in form a three-sided pyramid, directed vertically, and projecting from the middle of the face, so that the olfactory organ is the most anterior of all the organs of the special senses.

Its numerous varieties in shape and size fall under the consideration of painters rather than anatomists; for these varieties have greater effect upon the physiognomy than upon the exercise of its functions.

On each side of the nose, at its lower part, is observed a semicircular furrow, having its concavity directed downwards, and forming the upper border of the alæ nasi; from this furrow, on either side, the naso-labial furrow of the semeiologists commences. The lateral surfaces of the nose form, by their union, the *dorsum*, which is either straight, convex, or concave, according to the subject; differences which, in a great measure, determine the national or individual forms of this part of the face. The term lobe of the nose is applied to the rounded eminence in which the dorsum nasi terminates below.

The summit, or *root of the nose*, is separated from the nasal protuberance by a transverse furrow. The *base of the nose* presents two elliptical or semilunar orifices, called the *nostrils* (*nares*): the long diameters of these two orifices are directed horizontally backwards and outwards, and they are separated from each other by an antero-posterior septum; they are provided with stiff hairs, or *vibrissæ*, which serve to arrest any small particles floating in the air.*

The *direction* of the nostrils is a proof that the erect position is natural to man; for if he were to assume the attitude of a quadruped, only the dorsum of the nose would be directed towards odoriferous bodies. The situation of the nostrils above the orifice of the mouth, explains how no alimentary substance can be introduced into that cavity without having been previously examined by the sense of smell.

The nose consists of a skeleton or basis, and of certain muscles; it is covered by the skin externally, and by a mucous membrane internally; and it receives both vessels and nerves.

The Structure of the Nose.

The *basis* or *framework* of the nose is composed of *bone*, *cartilage*, and *fibrous tissue.*

The *osseous portion* occupies the upper part of the organ, and consists of the proper nasal bones, and of the ascending processes of the superior maxillary bones.

The *cartilaginous part* consists of the two *lateral cartilages of the nose*, to which we may add the *cartilage of the septum*, although it rather forms part of the nasal fossæ than of the nose properly so called; and, secondly, of the two *alar cartilages*, or *cartilages of the nostrils*, making five in all. To this we must add certain cartilaginous nodules, situated between the lower part of the cartilages of the alæ and that of the septum. Santorini described eleven cartilages in the nose, doubtless because he reckoned certain cartilaginous nodules, which are sometimes accidently developed in the substance of the fibrous tissue.†

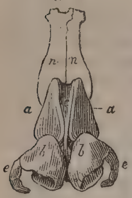
The *fibrous portion of the nose* consists of a fibrous layer, which occupies the interval between the lateral cartilages of the nose and the cartilages of the alæ.

* This use of the vibrissæ becomes very evident in serious diseases; when, in consequence of the hurried respiration, dry particles floating in the air become attached like a fine powder to these hairs. The collection of particles of dust around the nostrils often warns the practitioner of the serious nature of a disease.

† See note, p. 854.

From this structure it follows that the nose is inflexible above, flexible in the middle, and extremely movable below. This arrangement has the threefold advantage of providing against fractures of the most prominent part of the nose, of permitting the dilatation of the nostrils, and lastly, in consequence of the solidity of the highest and narrowest part of the nasal fossæ, of ensuring a free passage to the air.

Fig. 231.



The lateral cartilages of the nose (*a a*, *fig.* 231.) are of a triangular form; and they are united together along their anterior margins, which are thick above, so as to form a sharp ridge, which constitutes the dorsum of the nose. Along the line of union there is a sort of furrow or groove, which can be felt even through the skin. By their *upper* and *posterior* margins, they are articulated with the nasal bones; I say articulated, because there is no continuity of substance, but the parts are connected by fibrous tissue, which allows a considerable degree of motion. Their *lower margins* are convex, and correspond in front to the cartilages of the alæ of the nose, and behind to the fibrous tissue which occupies the intervals between the cartilages. The lateral cartilages are intimately united with the cartilage of the septum, along the dorsum of the nose; so that we might regard these three pieces as forming a single cartilage.

The thickest part of each lateral cartilage is above and in front.

The *cartilages of the nostrils* are generally called, after Bichat, the *fibro-cartilages of the alæ of the nose;* but we have already seen that some of the fibro-cartilages of Bichat are thin layers of ordinary cartilage, whilst others consist merely of condensed fibrous tissue. The so-called fibro-cartilages of the nostrils belong to the former kind. There is but a single cartilage on each side (*b b*, *fig.* 231.) for the ala nasi, the lobe, and the inferior portion of the septum; it consists of an irregular lamina folded upon itself into a semi-ellipse or parabola, opening behind. We shall examine its external and internal portions.

The *external portion* (*b*) is extremely thin, and corresponds to the ala of the nose: it is not situated in the substance of the ala, but is placed above it, so that its lower margin corresponds to the curved furrow which forms the upper boundary of the ala.*

The *internal portion* (*b*, *fig.* 232.) is thicker than the external, and is situated upon a lower plane than it: it corresponds, on the inside, to the internal portion of the cartilage of the opposite side, from which it is separated above by the cartilage of the septum. The internal portions of the two alar cartilages are separated from each other by some rather loose cellular tissue, which allows them to move upon each other, and also permits the cartilage of the septum to extend between them, without interfering with them at all. The internal portions of the cartilages of the alæ do not reach the anterior nasal spine, but terminate abruptly at a certain distance from it, by forming a projection, which is very distinct, especially in some individuals, and which sensibly elevates the mucous membrane at the entrance of the nostrils. At the point of union between the internal and external portions of each alar cartilage, that is to say, at the summit of the parabola, the cartilage itself becomes wider and excavated behind, and assists in forming the lobe of the nose. The margins of these cartilages are irregularly notched or scolloped. The upper margins are united to the other cartilages by means of a fibrous tissue, which allows them to move freely, both upon the cartilage of the septum and upon the lateral cartilages of the nose.

A small *cartilaginous nodule* is found on either side between the lobe of the nose and the cartilage of the septum; the only use of these nodules is to facilitate the movements of the lobe upon the septum.

* [Two or three cartilaginous nodules (*c c*, *fig.* 231.) are generally found appended in a curved line to the posterior extremity of this portion of the cartilage of the ala.]

The *cartilage of the septum nasi* (*c*, *fig.* 232.) occupies the triangular interval between the perpendicular plate of the ethmoid bone and the vomer. It consists of two parts: one, wide and free, which is that generally described; the other which is narrow, and may be called the *caudal prolongation of the cartilage*, is received into the bony portion of the septum, between the two lamellæ of the vomer.

Fig. 232.

The *free portion of the cartilage* is thick and triangular; it has the same direction as the bony septum, and presents *two lateral surfaces*, covered by the pituitary membrane; an *anterior margin*, of which the upper half (*c*, *fig.* 231.) is blended with the lateral cartilages along the dorsum of the nose, whilst its lower half is free, convex, directed downwards, and received between the two cartilages of the nostrils; a *superior and posterior margin*, which is extremely thick and rough, and is intimately united to the corresponding margin of the perpendicular plate of the ethmoid bone (*e*, *fig.* 232.): the mode in which this union is effected is not by articulation, but by a continuity of tissue, like that between the costal cartilages and the ribs; lastly, an *inferior margin*, which is received between the two plates of the vomer (*v*). The groove into which it is received is very deep; and as the two plates of the vomer become more and more separated in extending forwards, so does the corresponding margin of the cartilage increase in thickness; hence the lower extremity of the septum frequently projects considerably into one or other of the nostrils.

The *caudal prolongation of the cartilage* of the septum may be seen by carefully examining the retreating angle formed by the perpendicular plate of the ethmoid and the vomer; in which situation the cartilage of the septum gives off a considerable prolongation, in the form of a band, which occupies the interval between the two plates of the vomer, and is attached to the rostrum of the sphenoid bone. This cartilaginous band is contained entirely within the substance of the middle portion of the bony septum: its *upper margin* is thin, and, as it were, toothed; the *lower margin* is thick and rounded. The two naso-palatine nerves are situated in the same canal as the cartilage, and are placed one on each side of it.

The *muscles of the nose* are the pyramidalis nasi, the levator labii superioris alæque nasi, and the transversalis nasi or compressor narium, which we have described as a dependence of the depressor alæ nasi or myrtiformis: an accurate description of these muscles is still to be desired.

The *skin*, covering the nasal bones and the lateral cartilages of the nose, has no particular character: it is thin and moveable. That which covers the alæ and the lobe of the nose is very thick and extremely dense; it crepitates under the knife, to such a degree, that cartilages have been supposed to exist in the substance of the alæ. We have seen, however, that the cartilages of the nostrils are not prolonged into the alæ, which are composed essentially of the dense integument just described, and which is reflected inwards upon itself around the margins of the nostrils.

I should remark that the antero-posterior diameter of the opening of each nostril is much less than that of the corresponding cartilage; this depends upon the fact, that the skin is prolonged anteriorly, and is reflected for some lines below and behind the lower margin of the cartilage.

The skin of the nose is remarkable for the great developement of its sebaceous follicles. The orifices of these follicles are shown in many individuals by certain black points, which are nothing more than the sebaceous matter discoloured. When forced out of the follicles by lateral pressure, the masses of sebaceous matter resemble in form small worms.

The skin, which is reflected upon itself around the margins of the nostrils, preserves the character of integument as far as where it is provided with hairs, and then suddenly assumes the characters of *mucous* membranes.

The Pituitary Membrane.

The *pituitary* or *Schneiderian* * *membrane*, the immediate seat of smell, is a fibro-mucous membrane, which lines the whole extent of the nasal fossæ, and is prolonged, with some modifications of texture, into the different cells and sinuses which open into those fossæ.

When covered with this membrane, the nasal fossæ present a configuration differing in many respects from that which they have in the skeleton. Many of the foramina and canals are closed, and several are contracted in their dimensions. The irregularities of the surface of the turbinated bones are, in some measure, concealed. Besides this, the mucous membrane, where it is reflected upon itself, forms a number of folds, some of which prolong the turns of the turbinated bones; whilst others, more or less, contract the orifices of communication between the various cells and sinuses and the nasal fossæ.

The pituitary membrane, originating then, on the one hand, from the skin, which is reflected at the margins of the nares, and provided with hairs (*h*, *fig.* 233.), is, on the other hand, continuous, without any line of demarcation, with the mucous membranes of the pharynx and velum palati (at *t s*), of the Eustachian tubes (at *m*), and of the nasal ducts (at *r*). In the *roof of each nasal fossa* (*u v*) it closes the foramina of the cribriform plate of the ethmoid bone, and those of the nasal bones, so that all the vessels and nerves which pass through these foramina enter the mucous membrane by its external surface; before it enters into the sphenoidal sinus, it forms a fold around the orifice of that sinus, by which the opening is narrowed, so as to have the form of a vertical fissure (see the bristle marked *d*).

Upon the *external wall of each nasal fossa* (see *fig.* 233.) †, it covers a great number of parts, counting from below upwards, viz. the *inferior meatus*, at the upper and anterior part of which it meets with the lower orifice of the nasal duct (*r*, *figs.* 233, 234.); around this opening it forms a semilunar valvular fold, the free margin of which is directed downwards, and which prolongs the canal of the ducts to a greater or less distance in different subjects; in passing a probe into the nasal duct from the inferior meatus, this valve must, almost of necessity, be torn.

Fig. 233.

From the inferior meatus the pituitary membrane is reflected upon the *inferior turbinated bone* (*c c*, *figs.* 233, 234.), which appears longer in the recent state, in consequence of a fold of the mucous membrane being continued in front, and another still more marked behind the bone: this is the thickest part of the nasal mucous membrane.

In the *middle meatus* (*i*) the pituitary membrane covers the *infundibulum*, at the lower extremity of which is an ampulla or dilatation, where the *orifice of the maxillary sinus* is generally found. This orifice (see bristle, *a*, *fig.* 234.) has a very different appearance from that which it presents in the dried skull: it is extremely narrow, scarcely admitting the blunt end of a common probe.

* Conrad Victor Schneider (*de Catarrho*) gave his name to this membrane, because he was the first to refute successfully the erroneous notion of the ancients, that the secretion of the nasal fossæ descended from the ventricles of the brain; the common term, *cold in the head*, still remains as a vestige of this error.

† [In this figure, portions of the middle and inferior conchæ are represented as cut away, to show the parts in the middle and inferior meatuses.]

It sometimes appears as if it were wanting; but it will then be found opposite the middle of the infundibulum; in this case the maxillary sinus might be said to communicate directly with the frontal sinus. Not unfrequently the maxillary sinus opens both into the middle meatus and the infundibulum. The pituitary membrane is prolonged from the infundibulum into the anterior ethmoidal cells (*e e*, *fig.* 234.), and into the frontal and maxillary (*m m*) sinuses. If we remove the middle turbinated bone, we find a considerable projection, which bounds the infundibulum above (*n*, *fig.* 233.), and corresponds to a large ethmoidal cell. Upon the back part of this projection, on which the middle turbinated bone is moulded, an opening (see bristle) is often found leading into this great cell, and on its fore part (at *e*), one or more orifices leading into the anterior and superior ethmoidal cells.

From the middle turbinated bone (*b*, *figs.* 233, 234.), which is continued backwards by a fold of the membrane, the pituitary membrane passes into the superior meatus, where I have frequently met with four or five openings leading into as many of the posterior ethmoidal cells, which, in this case, did not communicate with each other: I have even seen the orifice of an ethmoidal cell upon the superior turbinated bone (*a*).

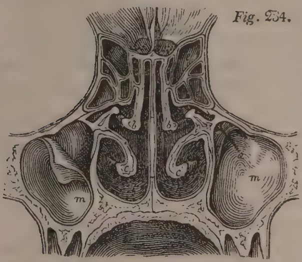


Fig. 234.

The pituitary membrane dips into all the ethmoidal cells, and into the frontal sinuses, either directly, or indirectly, but it does not enter the spheno-palatine foramen, which, on the contrary, is completely closed by it.

Upon the septum the pituitary membrane is remarkable for its thickness, being exceeded in this respect only by the membrane covering the inferior turbinated bone. We do not find in man that prolongation or cul-de-sac, which is so very distinct in some animals, in front of the lower border of the septum; but, at this point, the pituitary membrane closes the two superior orifices of the anterior palatine canal.

Structure. The pituitary membrane is a mucous membrane, and its peculiarity consists in its being extended over osseous and cartilaginous surfaces. Its free surface is smooth, red, and scattered over with foramina, from which a great quantity of mucus may be expressed.* Its adherent surface is intimately united to the periosteum and perichondrium of the bones and cartilages of the nasal fossæ, so that it is classed among the fibro-mucous membranes.

The pituitary membrane is generally thicker than the other mucous membranes, so that it is very easy to determine the highly vascular and truly erectile structure of this membrane. If it be punctured, and the tube of a mercurial injecting apparatus introduced, the mercury will immediately enter the cells of the erectile tissue, and from thence pass into the veins arising from those cells. If a more superficial puncture be made, a lymphatic network will be injected, situated so superficially, that the mercury exhibits all its metallic lustre. This lymphatic network has no communication with the venous cells just mentioned.†

This lymphatic network, which is common to all the mucous membranes, gives to the non-vascular layer by which they are covered the appearance of a serous membrane.

* [In the nasal fossæ the epithelium of the pituitary membrane is columnar and ciliated; in the sinuses it approaches the squamous in character, but yet it is provided with cilia, the movements of which have been observed in the lower animals to produce currents towards the openings of the respective sinuses.]

† It was in the pituitary membrane of the calf that, about eight years ago, I first accidentally injected the superficial lymphatic network.

The pituitary membrane receives a great number of *arteries*, which penetrate it by several points, and which are almost all derived from the same source, viz. the internal maxillary artery; as, for example, the spheno-palatine, the infra-orbital, the superior alveolar, the palatine, and the pterygo-palatine. Some arise from the ophthalmic artery, viz. the supra-orbital and the ethmoidal; and others from the facial artery, viz. the dorsalis nasi, the artery of the alæ, and the artery of the septum.

The capillary veins are so numerous, that they in a great measure form the basis of the pituitary membrane; the larger veins which proceed from them follow the course of the arteries, and enter, by very large trunks, into the internal maxillary, the facial, and the ophthalmic veins. There are numerous communications between these last named veins and those of the ethmoidal region of the base of the cranium.

The spongy character of the internal surface of the nasal fossæ, and more particularly of the surface of the turbinated bones, is due to certain grooves and foramina intended for the reception and transmission of bloodvessels.

I am only acquainted with the superficial *lymphatic* network already noticed. In order to inject it, it is necessary to scratch the membrane with the injecting pipe.

Are there any *glands* or *follicles* in the pituitary membrane? Steno has described certain glands which I have not been able to find. The follicles in this membrane are rather difficult to be shown.

Like all the organs of the special senses, the pituitary membrane is provided with a special nerve, called the *olfactory*, the nerves of the two sides constituting the *first pair* of cerebral nerves. Comparative anatomy shows that the developement of the olfactory nerves is in relation with the developement of the sense of smell, and thus establishes, in a most positive manner, the generally received opinion regarding the function of this pair of nerves. Without entering here into the description of the olfactory nerves, which will be given hereafter, I would observe that they pass through the foramina and canals of the cribriform plate of the ethmoid bone, at the same time becoming enveloped in fibrous sheaths; that they enter the pituitary membrane by its external surface; and that they expand into a plexus in its substance. The branches of these nerves cannot be traced lower than the middle turbinated bones on the one hand, and the middle of the septum on the other. Thus, while the upper and extremely narrow part of each nasal fossa (*s*, *fig.* 234.) is the essential seat of the sense of smell, the lower and much wider part only gives passage to the air during the act of respiration.

Besides the special nerve of smell, the pituitary membrane receives other nervous filaments, all of which are derived from branches of the fifth nerve, viz. from the internal nasal and the frontal branches of the ophthalmic division of that nerve, and from the spheno-palatine, the great palatine, the vidian, and the anterior dental branches of its second or superior maxillary division. The experiments of modern physiologists have shown that the integrity of these different branches of the fifth pair is necessary for the perfect possession of the olfactory sense. This, however, is very different from saying, that the seat of that sense is in the branches of the fifth pair.

The membrane which lines the several sinuses, although it is continuous with the pituitary membrane, does not resemble it in character; it is exceedingly thin and transparent, and appears like a serous rather than a mucous membrane; that it is a mucous membrane is satisfactorily established only by certain pathological facts. The mucous membrane of the sinuses has a very close resemblance to the conjunctiva.*

* See note, p. 858.

The Organs of Sight.

The *eyes*, or the organs of sight, are situated at the highest part of the face, so that they are enabled to explore objects at a distance.

They are two in number; but they co-operate in their function so as to act like a single organ. The result of this is that vision is rendered more certain, and its field of operation more extensive, at the same time that, from the unity of action of both eyes, it is *single*.

The eyes are protected by the orbital cavities in which they are contained; they are covered by the *eyelids*, and these are surmounted by the *eyebrows*. They are surrounded by *six muscles*, by which they can be moved in all directions; they are divided into the *straight* and the *oblique* muscles. There is also a secreting apparatus, the *apparatus of the lachrymal passages*, the secretion from which lubricates the anterior surface of the ball of the eye, and facilitates the exercise of its functions.

The study of the organ of sight, therefore, is not limited to that of the eyes alone, but includes that of the means of protection, viz. the orbital cavities (see Osteology), the eyelids, and the eyebrows; that of the muscles, or moving organs; and that of the lachrymal passages, or lubricating apparatus. These accessory parts, or appendages of the organ of vision, have been collectively named by Haller the *tutamina oculi*. We shall commence our description with them.

The Eyebrows.

The *eyebrows* are two arched ridges, which are covered with short stiff hairs, that are directed from within outwards, and over-lap each other; the eyebrows are situated at the lower part of the forehead, and form the boundary of the upper eyelid. Their direction corresponds precisely with that of the orbital arch. The hairs upon them are more numerous, and longer at the inner extremity, which is called the head, than at the outer, which is denominated the tail of the eyebrow. The heads of the two eyebrows are separated from each other by an interval which corresponds to the root of the nose; sometimes, however, they are blended together.

Structure. The skin in which the hairs of the eyebrow are implanted is thick, and very closely united beneath to a muscular layer formed by the frontalis, the orbicularis palpebrarum, and the corrugator supercilii, the last named muscle being situated beneath the other two. The orbital and superciliary arches serve as a basis to support the eyebrows; the nerves of these parts are very numerous, and are derived from the facial and the fifth nerves; their vessels arise from the ophthalmic and temporal arteries.

Uses. The eyebrows, which give a peculiar character to the human countenance, protect the eye, and, when depressed in front of it, intercept a great number of the rays of light; they assist in a remarkable degree in giving expression to the face.

The Eyelids.

The *eyelids* are two moveable and protecting curtains, placed in front of the ball of each eye, which they conceal or leave uncovered, according as they are in a state of approximation or separation.

The eyelids are two in number — a *superior* and an *inferior*. In a great number of animals there is a third eyelid, of which merely a trace exists in man. The eyelids are large enough to close the base of the orbit completely, and to intercept entirely the passage of light.

Each of the eyelids presents for our consideration a *cutaneous surface*, which is convex, and marked with concentric semilunar folds, that become effaced when the lids are closed; an *ocular surface* (*fig.* 235.), which is concave, is accurately moulded upon the ball of the eye, and presents a series of yellowish,

vertical lines, formed, as we shall see, by the Meibomian glands; an *adherent border*, which is indicated by the orbital arch in the upper eyelid, but is less clearly defined in the lower lid, in which it is continuous with the cheek; lastly, a *free border*, or margin, which, in both eyelids, is straight when the lids are closed, and curved when they are open: in the latter position they inclose an elliptical space (*rima palpebrarum*), the dimensions of which vary in different persons, and hence give rise to the expressions *large eyes* and *small eyes*, which have no reference to the actual size of the globe of the eye, but merely to the size of that part which is exposed to view. The free margins of the eyelids are not cut obliquely from before backwards, so as to intercept, when they are closed, a three-sided interval or channel, which is completed behind by the globe of the eye, and which is supposed to become larger from without inwards, in order to conduct the tears towards the lachrymal puncta. On the contrary, these margins are cut horizontally from before backwards (see section, *fig.* 240.); and when approximated, they leave a narrow fissure between them, which may serve as a channel for the tears during sleep, quite as well as the three-sided canal, which is generally supposed to exist.

The margins of the eyelids, moreover, are tolerably thick, and are furnished at their anterior lip with three or four rows of hard, stiff, and curved hairs, which are more numerous and longer on the upper than on the lower eyelid, and at the middle than at either end of each: these are the *eyelashes*. Their direction is worthy of notice: in the upper eyelid they are at first directed downwards, and are then curved upwards, so as to describe an arc having its concavity turned upwards: the eyelashes of the lower lid have just the opposite arrangement. From this it follows, that the convexities of the eyelashes of the two lids are turned towards each other; and thus, when the eye is shut, they touch each other without being able to interlace. Serious inconvenience is produced when the eyelashes deviate from their proper course, and are turned inwards; when the eyelashes are wanting, the free margins of the lids are attacked with chronic inflammation. Along the posterior lip of the free margin of each eyelid, or rather along the angular ridge formed by the union of that margin with the posterior surface of the lid, are placed a very regular series of foramina (*figs.* 235, 236.), from which the sebaceous matter secreted by the Meibomian glands may be expressed in masses having the form of small worms.

At the junction of the external five sixths with the internal sixth of the free margins of the two eyelids are found two very remarkable tubercles, the *lachrymal papillæ* or *tubercles* (*a*, *fig.* 239.; also seen in *figs*, 235, 236.), each of which is perforated by an opening, visible to the naked eye; these openings are the *puncta lachrymalia*, the orifices of the corresponding lachrymal canals. That part of the free margin of each eyelid which is on the inner side of the corresponding lachrymal papilla is straight, rounded, and destitute of hairs or follicular orifices; in the space inclosed between this part of the eyelids, and called *lacus lachrymalis*, is situated the *caruncula lachrymalis* (*, *fig.* 239.).

The upper eyelid, moreover, is twice as deep as the lower; so that, when depressed, it descends below the transverse diameter, or equator of the eye, to use an expression invented by Haller.

The terms *angles of the eye*, or *commissures of the eyelids*, are applied to the angles formed by the junction of the extremities of the free margins of the eyelids. The external angle, *external* or *temporal commissure* (*b*, *fig.* 239.), is also named the *little angle* (*canthus minor*).*

The internal angle, *internal* or *nasal commissure* (*e*), improperly called the *great angle of the eye* (*canthus major*), corresponds to the posterior border of the ascending process of the superior maxillary bone.

Structure of the eyelids. The constituent parts of the eyelids are, the tarsal

* The external commissure does not correspond to the outer extremity of the transverse diameter of the base of the orbit, but is situated about three lines nearer to the nose: hence the necessity of dividing this commissure in extirpation of the eye.

cartilages, a fibrous membrane, a muscular layer, two integumentary layers, one mucous and the other cutaneous, and certain follicles, with vessels, nerves, and cellular tissue.

The *tarsal cartilages*, which resemble in their use the cylinders of wood attached to the bottom of a map or diagram, to prevent it from hanging in folds, are two in number, one for each eyelid; they are cartilaginous plates, situated within the free margin and the contiguous portion of the lids. The tarsal cartilage of the upper eyelid (*a*, *figs.* 235, 236.) is semilunar; that of the lower eyelid (*b*) has the form of a small narrow band; neither of them occupies the entire length of the corresponding lid. Their anterior surface is convex, and is covered by the fibres of the orbicularis palpebrarum muscle. Their posterior surface (*fig.* 235.) corresponds to the conjunctiva, and is closely adherent to it. The Meibomian glands are situated between the conjunctiva and the cartilage, or rather in the substance of the cartilage.

The adherent border of each tarsal cartilage is thin, and affords attachment to the fibrous membrane of the lids; the adherent border of the cartilage of the upper eyelid, which is convex, also gives attachment to the levator palpebræ superioris muscle. The free margins of these cartilages are their thickest parts, and occasion the thickness of the free margins of the eyelids.*

The *cutaneous layer* is remarkable for its excessive tenuity and semi-transparency: the *eyelashes* are appendages of this part of the integument.

The *cellular layer* is no less remarkable for the absence of fat, than for its extreme delicacy: it is the type indeed of serous cellular tissue, and is frequently the seat of serous infiltrations.

The *muscular layer* is formed by the palpebral portion of the orbicularis muscle, the pale colour of which, as I have already noticed, contrasts with the dark red hue of the orbital portion of the same muscle. Besides this, the upper eyelid has an extrinsic muscle, the *levator palpebræ superioris* (*a*, *fig.* 237.), the tendon of which, however, is alone concerned in the formation of that eyelid, by being attached to the upper border of the corresponding tarsal cartilage.

The *fibrous layer* consists of a fibrous membrane, which arises from the margin of the orbit, and is attached to the corresponding borders of the tarsal cartilages. This membrane is very strong and unyielding in the outer half of the base of the orbit, but diminishes in thickness towards the inner half of that base, especially on the inner portion of the upper eyelid, where it degenerates into cellular tissue.

The term *ligament of the external canthus* might be applied to a fibrous raphé, which extends horizontally from that angle to the base of the orbit. This raphé bifurcates opposite the outer canthus, so as to become attached to the outer end of each tarsal cartilage, and it exactly corresponds to the tendon of the orbicularis palpebrarum, which is situated at the inner canthus, and which is also bifurcated, to join the inner ends of the same cartilages.

On cutting through this raphé, some very strong fibrous bundles are exposed, which arise from the external wall of the orbit, and spread out into the substance of the upper eyelid.

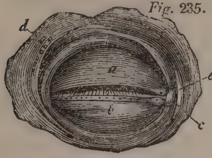
The expanded tendon of the levator palpebræ superioris, which is subjacent to the fibrous layer, completes the fibrous structure of the upper eyelid. The tarsal cartilages and the fibrous layer are situated upon the same plane.

The *mucous layer*, or *palpebral conjunctiva*, consists of a membrane which lines the posterior surface (*fig.* 235.) of the eyelids, and is moreover extended over the globe of the eye. This membrane is called the *conjunctiva*, or *tunica adnata*, because it connects the eyelids with the ball of the eye. In order to facilitate our description, we shall suppose it to commence at the free margin of the upper eyelid (*a′*, *fig.* 240.), where it is continuous with the skin: having

* [The substance of the tarsal cartilages differs from that of ordinary cartilage in being more opaque, and also in having a few microscopic filaments scattered through it; in this respect approaching in character to fibro-cartilage.]

covered the whole thickness of this margin, it then lines the posterior surface of the tarsal cartilage (c'), to which it is intimately adherent, and continues in the same direction as far as beneath the orbital arch. At this point it is reflected upon the anterior surface of the globe of the eye, so as to form a cul-de-sac between that organ and the eyelid: upon the eyeball, where it is called the ocular conjunctiva, it adheres to the sclerotic coat by means of cellular tissue, which is at first loose, but gradually becomes closer and closer as it approaches the transparent cornea. Upon the cornea (d') its adhesion is so intimate, that some anatomists have denied its existence in that situation. In fact, it can only be anatomically demonstrated in the healthy state upon the margin of the cornea, but its existence over the whole of that part of the eye is shown in some diseases. After having covered the anterior and inferior part of the sclerotic (c''), the conjunctiva is reflected upon the posterior surface of the lower eyelid (b'), lines its tarsal cartilage, covers its free margin, and then becomes continuous with the skin. On the inner side of the ball of the eye the conjunctiva forms a small semilunar fold, the *plica semilunaris* (*e*, *figs.* 235. 239.), which has its concavity turned outwards, and which may be regarded as the vestige of the third eyelid found in animals: it is misnamed the *membrana nictitans* (la membrane clignotante). On the outer side, the conjunctiva dips between the eyelids and the ball of the eye, and forms a deep cul-de-sac. Opposite the lachrymal papillæ the conjunctiva passes into the puncta, and lines the lachrymal passages.

Fig. 235.

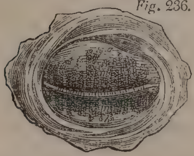


From what has been stated above it will be seen, that the conjunctiva would form a shut sac, like the serous membranes, if the eyelids were supposed to be united. Like the serous membranes, it covers two surfaces that rub one upon the other. Its tenuity, its transparency, and the filamentous adhesions which are sometimes observed between its contiguous surfaces, have induced some anatomists to place this membrane among the serous, rather than the mucous membranes; but its continuity with the skin, its extreme vascularity, and its uses, which require it to be in contact with the air, prove that it should be retained amongst the latter class of membranes.*

The *glands found in the eyelids* consist of an appendage of the lachrymal gland, which will be described with it, of the Meibomian glands, and of the caruncula lachrymalis.

The *Meibomian glands* (*m m*, *fig.* 236.) are situated upon the posterior surface of both eyelids, opposite the tarsal cartilages; they resemble yellowish vertical and parallel lines, sometimes straight and sometimes curved; their length is proportioned to the depth of the cartilages, and they never project upon the inner surface of the eyelids. Each of these lines, of which there are from thirty to forty in each eyelid, consists of a tortuous canal, folded upon itself a great number of times, and having a considerable number of small follicles opening into it on each side. All these canals open very regularly upon the posterior lip of the free margin of the lid by a row of orifices arranged in a single line. I have never seen two rows of openings, as Zinn states he has observed. If the eyelids be compressed over the tarsal cartilages by a pair of pincers, masses of a waxy substance exude from these orifices, having the form of small worms twisted frequently upon themselves. Sometimes these

Fig. 236.



* The absence of villi has been stated as characteristic of the conjunctiva; but villi or papillæ are found upon that portion which lines the superior tarsal cartilage.

[The epithelium of the conjunctiva is squamous, and consists of several layers; according to Henlé, it is ciliated upon the inner surface of the eyelid; but cilia have not been observed upon the eyeball.]

small linear canals communicate with each other opposite the adherent border of the tarsal cartilage; at other times they bifurcate. It is the waxy secretion from the Meibomian glands which prevents the tears from trickling in front of the eyelids. These glands are lodged in the deep grooves in the tarsal cartilages; they are, therefore, as visible upon the external as the internal surface of the cartilages.

The Meibomian glands belong to the class of sebaceous follicles, and form a transition, as it were, from follicles to glands.

The *caruncula lachrymalis* (*c*, *fig.* 235.; *, *fig.* 239.) consists of a small, oblong group of follicles, situated at the inner angle of the eyelids, and on the inner side of that semilunar fold of the conjunctiva, which we have spoken of as the trace of a third eyelid. It is about the size of a grain wheat. It is interposed between the free margins of the eyelids, in that part of those margins, which extends between the lachrymal tubercles and the internal commissure; but it is upon a plane posterior to these margins, so that it does not prevent their mutual contact. It is covered by a fold of the conjunctiva, which gives it a reddish aspect; it presents a great number of openings, through which a waxy secretion exudes, and projecting from it are several small hairs, which may become so long as to produce ophthalmia. The caruncula lachrymalis is composed of sebaceous follicular glands, of the same nature as the Meibomian glands. It was for a long time considered to be a second lachrymal gland. In order to obtain a good view of the orifices and of the light coloured and sometimes very numerous hairs of the caruncula lachrymalis, that body should be covered with ink, or a solution of carmine, and then examined with a lens.

Vessels and nerves of the eyelids. The arteries are the internal and external palpebral branches of the ophthalmic, and the palpebral branches of the temporal, infra-orbital, and facial arteries. I have already said that the palpebral arteries form two arches, one for each eyelid.

The *veins* have the same name, follow the same direction, and open into the corresponding venous trunks.

The *nerves* are derived from two sources, viz. the facial and the fifth nerve.

Uses. The eyelids protect the eye from the action of light and air, and of any particles floating in the latter; by a sweeping movement they clean the surface of the organ, over which they also spread the lachrymal fluid, which serves as a protection to the eyeball against the action of the air. The eyelids, from their capability of being interposed between the eye and external objects, place the exercise of vision under the control of the will.

The Muscles of the Eye, and the Levator Palpebræ Superioris.

The muscles of the eye are six in number, and are distinguished into the *straight* and the *oblique*. There are four straight and two oblique muscles. With these we shall also describe the levator palpebræ superioris.

Dissection. Remove the roof of the orbit by two cuts with the saw, meeting each other at an acute angle opposite the optic foramen; be careful that the inner cut does not injure the cartilaginous pulley of the superior oblique muscle. Dissect the origins of these several muscles from the deepest part of the orbit with the greatest care. They are arranged completely round the optic nerve (*o*, *figs.* 237, 238.) and the motor oculi nerves. Those which arise above the optic nerve are attached to the dura mater and periosteum, but not to the bone; but those which arise below the nerve adhere more closely to the bone. The inferior or small oblique muscle is the only one which does not arise from the bottom of the orbital cavity.

The Levator Palpebræ Superioris.

The *levator palpebræ superioris* (*a*, *figs.* 237, 238.), much thinner and narrower than the rectus superior which is subjacent to it, *arises* from the bottom

of the orbit, at the upper part of the margin of the optic foramen, or rather from the fibrous sheath given off from the dura mater around the optic nerve. It arises by short and radiated tendinous fibres, to which the fleshy fibres succeed, in the form of a thin flat muscle, that passes outwards in a line parallel with the axis of the orbit, is reflected upon the globe of the eye, and ends in an aponeurotic expansion, which is *inserted* in the upper border of the tarsal cartilage of the upper eyelid.

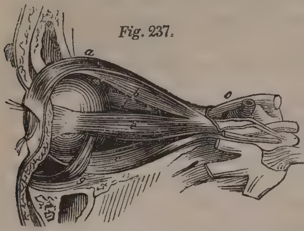


Fig. 237.

Relations. It is covered by the periosteum of the roof of the orbit, it is covered obliquely at its origin by the ophthalmic nerve, and it covers the superior rectus muscle.

Action. This muscle raises the upper eyelid, and draws it backwards, so that the upper border of the eyelid is concealed under the orbital arch.

The Rectus Superior or Levator Oculi.

The *superior rectus* (*b*) has two very distinct *origins.* The first resembles that of the levator palpebræ superioris in being from the upper part of the fibrous sheath of the optic nerve, but it is on a lower plane than that muscle; the second is from the inner margin of the sphenoidal fissure, *i. e.* between that fissure and the optic foramen. The latter origin, which is continuous with those of the external rectus, appears to take place from the sheath furnished by the dura mater to the third cranial or motor oculi nerve.

The fleshy fibres arising from this radiated tendon form a flat bundle, which passes forwards and outwards, in the direction of the axis of the orbit, and is reflected upon the eyeball, where it becomes converted into a broad and thin aponeurosis, and is *inserted* into the sclerotic coat, at a short distance from the cornea.

This muscle, like all the other recti, is in relation with the periosteum of the orbit, from which it is separated towards the inner side by the levator palpebræ superioris; it covers the optic nerve and the eyeball.

The Rectus Inferior or Depressor Oculi.

The *inferior rectus* (*c*) *arises* together with the internal and external recti by a common tendon, called the *tendon* or *ligament of Zinn*, which is attached to the lower half of the optic foramen, and more particularly to a depression which is seen to the inner side of the sphenoidal fissure. Almost immediately after its commencement this tendon divides into three branches, from the middle one of which the inferior rectus muscle arises, and then passing horizontally forwards and outwards, is reflected upon the globe of the eye, and terminates in a similar manner to the preceding muscle.

The Rectus Internus or Adductor Oculi.

The *internal rectus* (*d*) has two very distinct *origins*—one from the tendon of Zinn, the other from the inner side of the fibrous sheath of the optic nerve; the latter origin is continuous with those of the superior rectus. From these points it passes forwards along the internal wall of the orbit, is reflected upon the globe of the eye, and terminates like the preceding muscles.

The Rectus Externus or Abductor Oculi.

The *external rectus* (*e*) also has a double *origin* — one inferior, derived from the ligament of Zinn; the other superior, from the fibrous sheath of the sixth

cranial or abducens oculi nerve, and continuous with the external origin of the superior rectus. A fibrous arch under which certain veins pass, unites these two origins, and also serves as a point of attachment to the muscular fibres. From these points the muscle passes obliquely forwards and outwards along the external wall of the orbit, is reflected upon the eyeball, and terminates like the other recti muscles.

General Description and Action of the Recti Muscles.

The four straight muscles of the eye arise from the bottom of the orbit, and terminate upon the eyeball, a few lines from the cornea.

They all have the same form, viz. that of a long isosceles triangle, having its base turned forwards and its apex backwards. Their relations are also similar: thus they correspond, on the one hand, to the periosteum of the orbit, and on the other to the optic nerve and the globe of the eye, from which they are separated by some fat and vessels.

In consequence of their being inserted in front of the transverse diameter of the eye, they are all reflected upon the eyeball: this fact is rendered much more evident when the eye is drawn in an opposite direction to that in which the particular muscle under examination would act. Their tendons are surrounded with a whitish, and as it were elastic cellular tissue, by which the movements of these muscles are facilitated.*

The recti differ from each other, both in length and thickness. Thus, the internal rectus is the shortest and thickest, the external rectus is the longest, and the superior rectus is the smallest.

Action. If these muscles were not reflected upon the globe of the eye, their action would be simply to draw it forcibly backwards towards the bottom of the orbit; but in consequence of this reflection they can give it a rotatory motion. Thus, the superior and inferior recti rotate the eyeball upon its transverse axis, whilst the internal and external recti rotate it upon its vertical axis. After either of these effects is produced, the eye is then drawn backwards. The direct movement backwards is produced by the simultaneous contraction of the four muscles.

When any two *adjacent* recti act together, the eye is moved in the diagonal of the two forces exerted by those muscles; and hence the eye, and therefore the pupil, can pass over all the radii of the circle represented by the base of the orbit: this arrangement is not only highly favourable to the exploratory power of the eye, but also assists in placing the function of vision under the control of the will, since it enables us to turn away the eyes from any offensive object. The straight muscles of the eye, as well as the oblique muscles, also aid in expressing the passions: and hence the following names have been given to them by the ancients.—The superior rectus is called *superbus* (mirator, *Haller*); the inferior rectus, *humilis*; the external rectus, *indignatorius*; the internal rectus, *amatorius* seu *bibitorius*.

Lastly, it has been supposed that the muscles of the eye, by compressing that organ, can alter the distance between the retina and the crystalline lens; and a theory to explain the power we possess of adapting the eye for distinct vision at different distances, has even been constructed on the supposed possibility of this compression.

The necessarily simultaneous and co-ordinate action sometimes of the same muscle, and sometimes of different muscles in the two eyes, is a remarkable physiological fact. Thus, the contraction of the superior rectus of the right eye is of necessity accompanied by contraction of the corresponding muscle of left eye; whilst the contraction of the external rectus of one eye is accompanied by contraction of the internal rectus of the other eye, and *vice versâ*: the will can neither prevent nor disarrange these co-ordinate contractions.

* [Small synovial bursæ have been described as existing between these tendons and the globe of the eye.]

However, even without much practice, it is possible to overcome them, so far as to squint by endeavouring to look at the nose.

It is not uninteresting to remark that the sixth cranial nerve, or the abducens oculi, is destined exclusively for the external rectus muscle; and that the third cranial nerve, or motor oculi, supplies the three other recti, the levator palpebræ superioris, and the obliquus minor. No other muscles in the body receive such large nerves in proportion to their size as those of the eye.

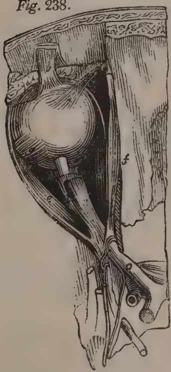
The Oblique Muscles of the Eye.

These are two in number, the *superior* or *great oblique*, and the *inferior* or *lesser oblique*.

The Obliquus Superior.

The *superior* or *great oblique muscle* of the eye (*f, fig.* 238.) is a long, filiform muscle, which is reflected over a pulley or trochlea, and hence has been termed the *trochlearis* muscle: it *arises* from the fibrous sheath of the optic nerve, between the superior and internal recti, in the same manner and upon the same plane as those muscles; from this point it passes forwards along the angle formed by the junction of the roof with the inner wall of the orbit, and forms a rounded muscular fasciculus, which ends in a rounded tendon near the cartilaginous pulley intended for its reception: the tendon passes through this pulley, is reflected upon itself at an acute angle, so as to be directed downwards, outwards, and somewhat backwards; gets beneath the superior rectus, where it spreads out, and is then *inserted* into the sclerotic coat *on a level* with the longest transverse diameter of the eyeball, and consequently further back than the insertion of the recti. The superior oblique is the longest muscle of the eye.

Fig. 238.



The *trochlea*, or *pulley* of the superior oblique, is a small cartilage, which forms five sixths of a short cylinder or ring; the edges of this imperfect cylinder are attached to the slight bony ridges which bound a depression upon the superior wall of the orbit. Its attachment is effected by means of loose ligamentous fibres, so that the pulley itself has a certain degree of mobility. The gliding of the parts is facilitated by a *synovial membrane*, which is reflected from the tendon upon the pulley, and is prolonged in front of and behind the latter. Beyond the pulley, a whitish filamentous tissue takes the place of the synovial membrane.

The *relations* of the superior oblique are similar to those of the superior rectus.

Action. Like all reflected muscles, the superior oblique must act from the point of its reflection. It follows, therefore, that this muscle rotates the eye upon itself from without inwards, that is, around its antero-posterior axis. From the oblique direction of its tendon from before backwards, after it is reflected, it can draw the eye forwards, and tends to bring it out beyond the orbit. This muscle is believed to assist in the expression of the tender passions (*musculus patheticus*). The fourth cranial nerve, also called the trochlear or pathetic nerve, is destined exclusively for this muscle.

The Obliquus Inferior.

The *inferior* or *lesser oblique* (*g, fig.* 237, 238.) is the shortest muscle of the eye, and the only one which does not arise from the bottom of the orbit: it *arises* from the inner and anterior part of the floor of that cavity, and, there-

fore, from the orbital surface of the superior maxillary bone, immediately behind the margin of the orbit, and often even from the lachrymal sac. From this origin it passes backwards, in the form of a flat bundle, which turns round the lower surface of the globe of the eye, situated at first between the eyeball and the inferior rectus, then between it and the external rectus, and at length ends in an aponeurotic expansion, which is blended with the sclerotic, near the outer border of the superior rectus.

Its insertion into the sclerotic is further back than that of the superior oblique; and, therefore, much further back than those of the recti.

Action. It rotates the eye in the opposite direction to the superior oblique. Its turning round the lower surface of the eyeball renders its action extremely effective. From its oblique course from before backwards it can draw the eye slightly forwards.

The Lachrymal Passages.

The term *lachrymal passages* includes both the apparatus for secreting and that for conveying away the tears, consisting of a secreting organ, named the *lachrymal gland*; of *excretory ducts*, which pour out the tears upon the conjunctiva; and of a second set of ducts, intended to absorb the tears and convey them into the nasal fossæ, comprising the *puncta lachrymalia*, the *lachrymal canals*, the *lachrymal sac*, and the *nasal ducts*. Such is the order in which we shall describe this apparatus.

The Lachrymal Gland.

The *lachrymal gland* (*glandula innominata* of the ancients) consists of two very distinct parts — an *orbital portion*, situated in the fossa on the roof of the orbit, and a *palpebral portion*, which is inclosed in the substance of the upper eyelid.

The first or *orbital portion* (*l*, *fig.* 207.), the only part generally described, is of an irregular semi-ovoid form, having its long diameter placed transversely. It varies in size in different subjects, but is generally about as large as a filbert.* Its upper surface is convex, and corresponds to the fossa in the frontal bone, to which it adheres, especially in front, by very distinct fibrous bands: its inferior surface is concave, and is in relation with the external rectus, and with a small part of the superior rectus. Its anterior border corresponds to the orbital arch, or rather to the fibrous membrane of the eyelid, immediately behind which it is situated; hence it may be exposed by an incision along this arch. By its posterior edge it receives its vessels and nerves.

The second or *palpebral portion*, though continuous with the first, is separated from it by several fibrous bands. It forms a thin granular layer, which is covered and concealed by a very dense lamina of fibrous tissue that appears to be prolonged into its interior. This palpebral portion occupies the outer portion of the upper eyelid, and extends almost as far as the upper border of the tarsal cartilage.

The excretory ducts of the lachrymal gland. Before the discovery of these excretory ducts, it was only by inference that the so-called *glandula innominata* was regarded as the secreting organ of the tears. In 1661 Steno discovered these ducts in the sheep, in which animal they are large enough to admit bristles. He described thirteen or fourteen ducts. The difficulty of detecting these ducts in the human subject is sufficiently proved by the fact, that neither Morgagni, Zinn, and Haller, could ever find them; the second Monro, however, succeeded in filling them with mercury, and described them accurately. They are from ten to twelve in number; they run parallel to each other beneath the palpebral conjunctiva, and open upon the inner surface of the eyelid by a corresponding number of orifices (*d*, *fig.* 235.), placed very regularly about a line from the tarsal cartilage along its outer half. MM. Chaussier and Ribes

* [It has all the anatomical characters of a compound gland.]

have succeeded in filling them with mercury, by injecting them from the gland towards the eyelids. Having sought in vain, both with the naked eye and with a lens, for the orifices of the excretory ducts of the lachrymal gland in the human subject, I thought of dipping the eye and eyelids in a solution of carmine, or slightly diluted ink; and I then saw distinctly a dozen openings arranged in a line along the point of reflection of the palpebral conjunctiva upon the eyeball, and occupying the outer half of the eyelid.*

The Lachrymal Puncta and Canals.

The *puncta lachrymalia* (*a, fig.* 239.), two in number, one for each eyelid, are those small orifices or *foramina* which are visible to the naked eye in the centre of the lachrymal papillæ: they are perfectly circular, are always open, and are directed backwards; the upper one being turned downwards, and the lower one upwards. These openings, which are kept apart from each other by the caruncula lachrymalis, are the capillary orifices of two small canals, called the *lachrymal canals.*

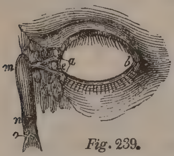


Fig. 239.

The *lachrymal canals* (*l l*) are small tubes, extending from the puncta lachrymalia to the lachrymal sac. They are two in number, a superior and an inferior, each being somewhat larger than the corresponding lachrymal punctum. Their angular course is very remarkable. They pass at first vertically, the superior duct upwards and the inferior duct downwards, and after a short course they bend abruptly at right angles, run inwards, and open by separate orifices, never together, into the anterior and external part of the lachrymal sac. The direction of the second portion of each of the lachrymal canals varies according as the eyelids are closed or open: the duct of the lower eyelid is directed somewhat obliquely upwards, that of the upper eyelid downwards, even when the lids are completely closed; but they are both very oblique when the eyelids are separated; and as this separation is principally due to the elevation of the upper eyelid, it follows that the obliquity of the upper lachrymal canal must be very well marked.

The coats of the lachrymal canals are dense and elastic, so that they do not collapse when empty, and must therefore act as capillary tubes. We do not find any sphincter, either at their palpebral or their nasal orifice; they appear to be formed in the substance of the free margin of each eyelid; they are lined by a prolongation of the conjunctiva, and are covered by the fibres of the orbicularis palpebrarum muscle. Behind them are found some muscular fibres, forming a dependence of a small fasciculus, called the *muscle of Horner*, or the *lachrymal muscle*, which was believed by that anatomist to serve in drawing the lachrymal ducts inwards.

The Muscle of Horner.

Dissection. Turn the eyelids inwards, and carefully remove a fibrous layer which covers this muscle upon the lachrymal sac.

This small muscle *arises* from the vertical ridge of the os unguis, which forms the posterior border of the lachrymal groove; from this point it passes transversely outwards along the posterior tendon of the orbicularis palpebrarum, and divides into two tongues, a superior and an inferior, which correspond to the lachrymal canals, and terminate at the respective lachrymal puncta.

I regard these fibres as a dependence of the orbicularis palpebrarum.

* I find in Haller, that it was in a human eye which had been macerated for some time in water tinged with blood, that Monro (Secundus) discovered these orifices. After they have been discovered, it is easy to introduce the end of the mercurial injecting pipe into them.

The Lachrymal Sac and Nasal Duct, or Lachrymo-nasal Canal.

The *lachrymal sac* and *nasal duct* constitute a single canal, which extends from the upper part of the lachrymal groove to the inferior meatus of the corresponding nasal fossa.

The *lachrymal sac* (*m*), that portion of the lachrymo-nasal canal which occupies the lachrymal groove, represents the half of a cylinder terminating above in a cul-de-sac. It is buried, so to speak, in the substance of the inner wall of the orbit, immediately behind the margin of that cavity, and is in relation with the inner angle of the eyelids, the caruncula lachrymalis, the adipose tissue of the orbit, and the tendon of the orbicularis muscle. The last named relation is one of the most important points in the anatomy of the lachrymal sac. If a circular incision be made through the eyelids from their outer angle along their adherent borders, and the lids be then turned inwards, by then carefully dissecting the tendon of the orbicularis, it will be found that that tendon divides into three branches; that the anterior branch, called the *straight tendon*, is inserted in front of the ascending process of the superior maxillary bone; that the posterior branch, which is of equal size with the anterior, is inserted into the ridge upon the os unguis, behind the lachrymal groove; that the middle branch ascends to be attached to the upper part of the lachrymal groove; and, lastly, that the lower part of the tendon gives off a fibrous expansion, which forms the outer side of the lachrymal sac, and which may be regarded as a fourth tendinous expansion. The muscle of Horner lies upon the posterior of these tendons, and must be regarded as a portion of the orbicularis itself.

The tendon of the orbicularis palpebrarum corresponds to the upper part of the lachrymal sac, only its cul-de-sac projecting above the tendon. The greatest part of the sac is therefore situated below it.

The internal surface of the lachrymal sac presents the ordinary appearance of all canals lined by mucous membrane: a considerable quantity of mucus is often found in it. At the anterior part of its external wall, and at about an equal distance from the top and bottom, are the two orifices of the lachrymal canals; above, is the narrow cul-de-sac, in which it terminates in that direction; and below, it becomes continuous with the nasal duct: in this place there is rather frequently found a semilunar, sometimes even a circular valve; this is the kind of diaphragm spoken of by Zinn, but the existence of which was denied by Morgagni. Haller says that he only met with it once.

The lachrymal sac consists of a partly bony and partly fibrous canal, lined by a mucous membrane. The *bony portion* of this canal is formed by the groove upon the ascending process of the superior maxillary bone and upon the os unguis; the last mentioned bone, which is thin and pierced with foramina, may be easily perforated; and hence the facility of making an artificial passage for the tears. The lachrymal sac is opposite to the middle meatus of the corresponding nasal fossa.

The *fibrous portion* forms the external flattened wall of this canal; it is very strong and unyielding, unless to long continued extension.

The slight *muscular layer*, described as the *muscle of Horner*, may be regarded as belonging to the lachrymal sac: this muscle is itself covered by a layer of fibrous tissue.

The lining *mucous membrane* of the lachrymal sac is reddish, and as it were pulpy, and closely resembles the pituitary membrane *; from its close attachment to the periosteum of the walls of the canal it might be called a *fibro-mucous membrane.*

The *nasal duct* (*n*), which may be said to be formed in the outer wall of the corresponding nasal fossa, extends from the lachrymal sac to the anterior part of the inferior meatus of the nose. It is of a cylindrical shape, slightly flattened on the sides, and rather narrower at the middle than at its extremities.

* See note, p. 870.

It is directed vertcially, but forms a slight curve, having its concavity turned forwards and outwards. It may be also readily conceived, that the relative breadth of the root of the nose must affect the direction of this canal.

It corresponds *on the inner side* to the middle meatus of the nose and the inferior turbinated bone ; *on the outer side* to the maxillary sinus, from which it is separated by a very thin lamina of bone. This latter relation has doubtless led one anatomist to state, that the nasal canal opens both into the maxillary sinus and the nasal fossa.

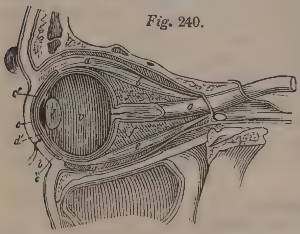
The nasal canal consists of a bony canal lined by a fibro-mucous membrane ; the bony canal is complete, and is formed by the superior maxillary bone, the os unguis, and the inferior turbinated bone. It is very strong in the part formed by the superior maxillary bone, excepting opposite to the sinus in that bone, but it is very thin and fragile where it is formed by the os unguis and inferior turbinated bone. Its lining membrane is of a fibro-mucous structure ; it adheres very slightly to the walls of the canal, and is continuous, on the one hand, with the mucous membrane of the lachrymal sac, and on the other with the pituitary membrane.* This lining membrane is often prolonged for several lines beyond the nasal duct, so as to form a valvular fold (*o*). Where this fold exists, the inferior orifice of the nasal duct (see *r*, *fig.* 233.) is always closed, and therefore difficult to be detected, even when the inferior turbinated bone has been taken away or displaced ; so that, in order to discover it, it becomes necessary to introduce a probe through the lachrymal passages from above. In catheterism of the nasal duct, from below upwards, according to the method practised by Laforest, this fold of mucous membrane must of necessity be torn.

It has been stated by some authors, that the lower orifice of the nasal duct is preceded by an ampulla, or infundibuliform dilatation. I have met with this disposition, but regarded it as morbid. I am convinced that a great many lachrymal tumours depend upon contraction or obliteration of the lower orifice of this canal.

The Globe of the Eye.

The *globe of the eye* (*v*, *fig.* 240.) is *situated* in the fore part of the orbital cavity ; it is retained in this situation by the optic nerve (*o*), the straight and oblique muscles (*b e g*), the vessels, the conjunctiva (*d*), and the eyelids : these parts, however, do not confine it in a fixed position, but allow it great mobility. In fact, the eye can be rotated around all its axes, and can even be drawn forwards and backwards (see *Muscles of the Eye*). The eyes are small in comparison to the orbital cavities ; and they present some slight differences as to size in different persons, which have not yet been properly estimated. The common terms *large* and *small* eyes, apply less to the eyeball than to the opening between the eyelids. The eye is proportionally larger in the fœtus and new-born infant than in the adult and aged.

Fig. 240.



In *form*, the globe of the eye resembles a regular spheroid, to the front of which is attached a segment of a smaller sphere (see *fig.* 241.) : by this arrangement, the antero-posterior diameter of the organ is increased to the length of eleven lines, whilst its other diameters are only ten lines. It is said that the form of the eyeball can be altered by the contraction of its muscles,

* [The epithelium of the mucous membrane of all the lachrymal passages is columnar, and, according to Henlé, is provided with cilia, although Purkinjé and Valentin failed to discover them in these situations.]

but in consequence of the great tension of this organ, the alteration produced is so slight that it scarcely deserves to be mentioned.

The *general relations* of the eyeball are the following: *in front*, it is covered by the conjunctiva and the eyelids, which defend it from light and from dust, rather than from external violence. It results also from the obliquity of the margin of the orbit, that, on the outer side, the eye projects considerably beyond the bones. In every other part of its surface, the eye rests upon an elastic cushion of fat (*f f*), which separates it from the muscles and nerves, fills up all intervals, and facilitates the movements of the organ. The absorption of this fat in emaciated individuals causes the depression of the eye into the orbital cavity. A membranous cellular tissue, or rather a rudimentary synovial membrane, exists between the eye and this fat.

Structure. Like all the other organs of the senses, the eye consists essentially of a membrane provided with a special nerve, and of a particular apparatus, placed in relation with the external agent by which the organ is to be acted upon. In the organ of vision, the sentient membrane is the retina, which is the immediate seat of the sense of sight: the other parts of the eyeball form nothing more than a very complicated dioptric instrument, a dark chamber, in which the rays of light are refracted, and concentrated so as to form a vivid image, and which is moreover provided with a moveable diaphragm to regulate the number of rays to be admitted.

In an anatomical point of view, the eye is said to consist of certain membranes and humours. The membranes, counting from without inwards, are the *sclerotic coat* and *cornea*, the *choroid coat* and *iris*, and the *retina*. The humours are, the *vitreous body* and its *hyaloid membrane*, the *crystalline lens* and its *capsule*, and the *aqueous humour*.

The Sclerotic.

Dissection. Clean the globe of the eye, leaving the attachments of the muscles to the sclerotic coat; with a pair of strong scissors divide this coat circularly into an anterior and posterior portion, taking care to avoid the choroid coat; turn the one portion forwards and the other backwards. It is easier to make this section without injuring the choroid upon a slightly flaccid eye than upon one which is perfectly fresh.

The *sclerotic* (σκληρὸς, hard), or the *opaque cornea* (*b*, *fig.* 241.), is the outermost of the coats of the eye, and forms as it were the shell of that organ; it is of a pearly white colour, and very strong: it is perforated behind to give passage to the optic nerve (*o*), and presents a circular opening in front (from *a* to *a*), into which the cornea is fitted.

Its *external surface* forms the outer surface of the eyeball, and therefore has the same relations. Thus, it is covered in front by the conjunctiva which adheres to it by means of very loose cellular tissue, that is liable to infiltration. The straight and oblique muscles of the eye are implanted into it. An imperfect or rudimentary synovial capsule separates it from the cushion of fat, and gives it a smooth aspect.

Its *internal surface* has a dull, rough appearance, very different from that of its external surface: it is, moreover, of a deep brown colour, from the choroid pigment; it corresponds to the choroid coat (*c*), and is united to it by a very delicate cellular tissue, and by the ciliary vessels.* The ciliary nerves run from behind forwards between the sclerotic and the choroid, occupying slight grooves upon the internal surface of the former. Both the ciliary vessels and nerves perforate the sclerotic coat very obliquely.

Structure. The sclerotic is one of the thickest and strongest fibrous membranes in the body: it is not of uniform thickness throughout; it is thickest behind at the entrance of the optic nerve, and thinnest in front near the cornea. Like all the fibrous membranes, it is unyielding; and on this depends the

* See note, p. 873.

firmness and tense condition of the globe of the eye: it is also the cause of the intense pain produced by inflammation of the interior of the eye and by certain cases of hydrophthalmia.

The older anatomists considered the sclerotic to be composed of two layers, the inner of which was, according to Zinn, a prolongation of the pia mater; and, according to Meckel, of the arachnoid. But, independently of the fact that the division of the sclerotic into two layers is purely artificial, it may be stated that neither the pia mater nor the arachnoid is prolonged upon the optic nerve. Lastly, the sclerotic has been regarded as a continuation of the dura mater, through the medium of the neurilemma of the optic nerve; and this view is supported by dissection, which shows clearly that the sheath furnished by the dura mater to the optic nerve is prolonged upon the sclerotic. It has, moreover, been stated, but incorrectly, that the anterior part of the sclerotic has an additional layer, formed by the union of the tendons of the recti muscles.

The sclerotic is composed of fibrous bundles which interlace in all directions.

Its *use* is especially to protect the globe of the eye, of which it forms the covering, and determines the shape.

The Cornea.

The *transparent cornea* (*a a*, *fig.* 241.) completes the external shell of the eye in front: in reference to the sclerotic coat, it represents a segment of a smaller sphere superadded to a larger sphere; its circumference is circular, or rather slightly elliptical, for its transverse diameter is half a line longer than its vertical diameter.

Its *anterior surface* is convex, and projects forwards beyond the sclerotic; it is covered by the conjunctiva, which adheres to it so closely, that the existence of that membrane upon it has been denied by some anatomists. *

Too great a convexity of the cornea, by increasing the refracting power of the eye, occasions myopia, or short-sightedness.

Its *posterior surface* is concave, and forms the anterior wall of the anterior chamber of the eye. A thin membrane (*m*) covers this surface, and is called the *membrane of the aqueous humour*.

The *circumference* of the cornea, which is fitted into the opening in the front of the sclerotic, is cut obliquely, so that its external surface is smaller than its internal surface; the oblique edge of the sclerotic, to which it corresponds, is sloped in the opposite direction.

The cornea and sclerotic adhere so closely that they were for a long time regarded as forming but one coat; but, independently of their difference in appearance and texture, they may be separated by boiling or by long-continued maceration.

Structure. The cornea is thicker than the sclerotic: it may be separated into a great number of lamellæ, united by very thin layers of cellular tissue; but this separation is purely artificial, so that the number of lamellæ is indefinite. The thinnest layer of fluid interposed between the lamellæ is sufficient to impair the transparency of the cornea; maceration, accordingly, gives it a milky appearance. The opacity of the cornea, which occurs in some cases of ophthalmia, depends upon the infiltration between the lamellæ of a certain quantity of fluid, after the absorption of which the cornea recovers its original transparency.

No vessels can be shown in the cornea, even by the aid of the finest injections of the arteries and veins of the eye: its superficial layer, which is continuous with the conjunctiva, contains a network of lymphatics communicating with those of the conjunctiva, and capable of being demonstrated by

* A careful dissection, especially after prolonged maceration, shows the continuity of the most superficial layer of the cornea with the conjunctiva. A malformation sometimes occurs, in which one part of the cornea is covered by a prolongation of the conjunctiva.

puncturing any part of the superficial layer of the cornea. It is useless to introduce the tube deeper, for the lymphatic network is entirely superficial.

Uses. The transparent cornea is the first medium through which the rays of light have to pass; in consequence of its density and its convexity, it refracts the rays of light and causes them to converge. The density of the cornea is the same in different persons; but its convexity is subject to variations, upon which depend in a great measure the states of myopia (short sight), presbyopia (long sight), and natural vision.

The Choroid Coat, and the Ciliary Circle and Processes.

The *choroid* (indicated by the thick black line, *c*, *fig.* 241.), so called from its extreme vascularity *, is the second membrane of the eye, proceeding from without inwards; it is a vascular membrane, covered with a thick layer of pigment: it exactly lines the sclerotic, and terminates like it at the circumference of the cornea.

Its *external surface* (*c*, *figs.* 242. 244.) adheres to the sclerotic by means of the ciliary vessels and nerves, and by a thin and very delicate cellular tissue, which is easily lacerated, and when raised appears like a spider's web. † This surface, when magnified, has a flocculent appearance.

Its *internal surface* is in relation with but does not adhere to the retina (*r*, *fig.* 241.), by which it is lined nearly throughout its whole extent.

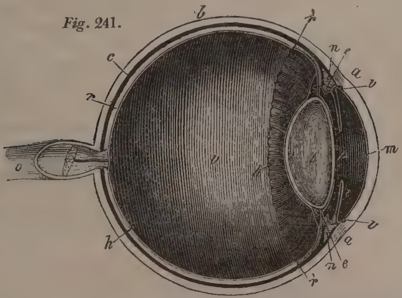
Both surfaces of the choroid are covered with a pigment which resembles the pigment of the skin of negroes; this pigment is much more abundant on the internal than on the external surface, and less so behind than in front, where it forms a thick layer in the form of a zone surrounding the corona ciliaris.

Upon both surfaces are found innumerable, longitudinal, and contorted lines, which correspond to the vessels of the choroid.

In a great number of animals — in the ox, for example, the pigment on the internal surface of the choroid at the back of the eye is replaced by a brilliant metallic-looking substance, called the tapetum. When deprived of its pigment, the internal surface of the choroid presents a smooth aspect, and is not flocculent like the external surface. It is of a greyish white colour; and anteriorly, where it is covered by a thick layer of pigment, it becomes white and shining when the pigment is removed.

Behind, the choroid is pierced by a circular opening for the passage of the optic nerve; *in front*, it terminates in the *ciliary circle* and *ciliary processes*, which must be regarded as appendages to it.

Fig. 241.



The ciliary circle. The *ciliary circle*, *ring*, or *ligament* (*n*, *fig.* 241.; *b*, *figs.* 242. 244.), is a circular zone, from a line to a line and a half in breadth, of a greyish colour, and soft consistence, which bounds the choroid coat (*c c*) in front. It is of considerable thickness. Its external surface corresponds to the sclerotic, to which it is slightly adherent. Its internal surface corresponds to the ciliary processes (*e*, *fig.* 241.); by its outer or larger border, which is distinguished from the choroid by a slight ridge, it receives the ciliary nerves (*a a*, *fig.* 242.), which bifurcate, and appear to anastomose with

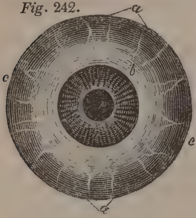
* Choroid is synonymous with vascular.

† [A serous cavity is said by some to exist between the sclerotic and choroid; the lining membrane of this supposed cavity is named the arachnoid membrane of the eye.]

each other before they enter the substance of the ciliary circle: by its lesser or inner border, which corresponds to the iris (*i*), it adheres intimately to the circumference of the cornea, exactly where that membrane is continuous with the sclerotic (at *a a*, *fig.* 241.). The older anatomists called this structure the *ciliary ligament*. From the great number of the nerves which enter the ciliary circle, from its greyish colour, and its pulpy aspect, modern anatomists have regarded it as a nervous ganglion (annulus gangliformis, or annular ganglion, *Soemmerring*).

Some anatomists describe, under the name of the *ciliary canal* or the *canal of Fontana*, a very small and extremely narrow circular space (*v v*, *fig.* 241.), which is formed between the ciliary circle, the cornea, and the sclerotic. This space can be filled with injection, and it is not certain that it is not the cavity of a bloodvessel.

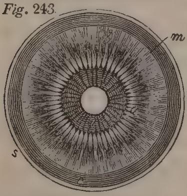
Fig. 242.



Anterior view.

The ciliary processes and the ciliary body. If the back part of the sclerotic, choroid, and retina be cut away, or even if the globe of the eye be merely divided into an anterior and posterior half by a circular incision, on looking into the anterior half a perfectly regular radiated disc (*d*, *fig.* 241.; *a b*, *fig.* 243.) will be seen around the crystalline lens. This disc, which has been very correctly compared to a radiated flower, is called the *ciliary body*, or *corona ciliaris;* each of the rays is called a *ciliary process* or *ray* (rayon sous-irien, *Chaussier*). If, after a correct idea of the arrangement of this radiated disc has been obtained, the choroid coat be separated from the humours of the eye, it will be found that there are two perfectly distinct discs: one of these remains attached to the choroid coat, and constitutes the *ciliary disc* or *ciliary body of the choroid* (*a b*, *fig.* 243.); the other remains attached to the vitreous body and to the crystalline lens, and is the *ciliary zone of Zinn*, which may be termed, after M. Ribes, the *ciliary processes of the vitreous body* (*a b*, *fig.* 248.). We shall now describe the ciliary processes of the choroid coat only, leaving the ciliary processes of the vitreous body to be described together with that part of the eye.

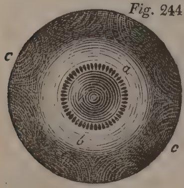
Fig. 243.



Posterior or internal view.

The ciliary processes of the choroid coat, so well described by Zinn, who enumerates sixty of them, are regarded as so many folds of the internal layer of the choroid. They may be divided into *great* and *small;* the latter occupying the intervals between the former. They all increase in size (from *b* to *a*, *fig.* 243.) as they approach the outer border of the iris, behind which they are prolonged without adhering to it, and are then bent forwards upon themselves to be attached to that border. These ciliary processes, the sides of which are turned towards each other, have therefore a posterior *adherent* or *choroid portion* (*b*), and an anterior *free* or *iridian portion* (*a*). The free portion (*e e*, *fig.* 241; *a*, *fig.* 244.) floats among the humours of the eye like a fringe; the slightest agitation of the vessel or of the liquid in which the ciliary processes are contained is immediately communicated to this free portion of the corona ciliaris.

Fig. 244.



Anterior view — iris removed.

The *ciliary body* or *disc*, which is formed by the union of all the ciliary processes or rays, is in relation behind with the vitreous body (*v* in the centre, *fig.* 241.), and advances (*e*, *fig.* 241.; *a*, *fig.* 244., in which the iris is removed) over the circumference of the crystalline lens. It is not simply in contact with the vitreous body, but is rather firmly adherent to it; and we shall afterwards

see that they are dove-tailed together, that is, the ciliary processes of the vitreous body are fitted into the intervals between the ciliary processes of the choroid, and *vice versâ.*

If the thick layer of pigment, with which they are covered, be removed, the ciliary processes of the choroid, when examined through a lens under water, have a white colour. In their substance are seen irregular cells which are filled with the brown pigment, and which give them a spongy, and as it were jagged, appearance. They are evidently continuous with the choroid, which immediately around them presents a zone of a whiter colour than the rest of the inner surface of that membrane.

Structure of the choroid coat and its ciliary processes. The structure of these parts is essentially vascular. Fine injections thrown into the carotid artery and internal jugular vein, in young subjects, fill a beautiful network of vessels in this membrane. The *vorticose* arrangement (*v*, *fig.* 244.) of some of these vessels is then clearly displayed, and indeed this is very well indicated, without the aid of an injection, by the striæ already described as visible upon the surfaces of the choroid. The short ciliary arteries belong exclusively to the choroid coat. From a great number of experiments made by M. Ribes, it would appear that injections pushed into the arteries do not enter the villi and fringes of the ciliary body, but that their vessels may be filled from the veins; so that, according to this, the structure of the free and fringed portion of the ciliary processes is altogther venous, like the cavernous or erectile tissues.*

From the different appearance of the external and internal surfaces of the choroid, anatomists have regarded this coat as being composed of two layers, of which the internal is called the *membrana Ruyschiana*, after Ruysch, who has given the best description of it. According to one view, which is not altogether unsupported, the internal layer alone concurs in the formation of the ciliary processes, whilst the external layer corresponds to the ciliary ring.

The Iris.

The *iris* (*i*, *figs* 242, 243.), so called on account of the varied colours which it presents, is a membranous vertical septum, perforated in the centre, like the diaphragm of an optical instrument. By means of this septum (*i*, *fig.* 241.), the space (*p*) between the cornea (*m*) and the crystalline lens (*l*) is divided into two parts or *chambers*, an *anterior* and a *posterior*. The iris is circular, and perforated in its centre by an opening which constitutes the *pupil* (*p*, *fig.* 242.), vulgarly, the apple of the eye, and which is surrounded by the *lesser* or *inner border of the iris;* the pupil is circular in the human subject, and oblong, either transversely or vertically, in the lower animals; the number of luminous rays suffered to impinge upon the retina are regulated by variations in the size of this opening. We constantly find in several kinds of animals, and occasionally in the human subject, small fringes attached to the lesser border of the iris, which float in the aqueous humour.

The *outer* or *greater border of the iris* is, as it were, fitted in between the ciliary ligament, which projects beyond it slightly in front, and the ciliary processes which encroach upon it behind (see *fig.* 241.). The manner in which it adheres to these parts is not well understood. There is a true continuity of tissue, and yet they may be separated by a slight degree of force; on this is founded the operation for *artificial pupil* by detaching the iris. The outer border of the iris is not continuous with the circumference of the cornea.

The *anterior surface of the iris* (*i*, *fig.* 242.) with its different shades of colour, is the part which is seen through the transparent cornea; it is plane, not convex. The interval between it and the cornea constitutes the anterior chamber of the eye (*fig.* 241.). The form and size of this interval can be cor-

* [In successful injections, arterial as well as venous ramifications are demonstrated in the ciliary processes.]

rectly estimated in a frozen eye: it is filled with the aqueous humour; its longest diameter from before backwards is about one line.

When examined with a lens, the anterior surface of the iris has a *flocculent* appearance, more distinct than, but similar to, that of the external surface of the choroid. It appears as if it were fissured here and there, and in the human subject presents some very well marked radiated bands. When the pupil is contracted these radiated bands are straight, but during its dilatation they become flexuous. They appear to interlace, and thus to become blended with each other near the pupil. It is generally admitted that the membrane of the aqueous humour covers the anterior surface of the iris; but it cannot be demonstrated in that situation. The colour of this surface differs in different individuals, and it has generally some relation to that of the hair; upon these differences depend the colour of the eyes, whether blue, black, grey, &c. Whatever may be the colour of the iris, two shades of different intensity may be distinguished in it, and occasion the appearance of two concentric coloured zones in this membrane; the smaller and deeper coloured zone is situated near the pupil; the larger and lighter coloured one includes the two outer thirds of the membrane. It is not always easy to distinguish these two zones.

The *posterior surface* (*i*, *fig.* 243.) of the iris corresponds to the crystalline lens, from which it is separated by an interval filled with the aqueous humour, and called the *posterior chamber of the eye* (*fig.* 241.).

The two chambers of the eye, therefore, communicate at the pupil (*p*).

The posterior surface of the iris is covered by a thick layer of pigment, which is continuous with the pigment of the choroid: near its outer border it is also overlaid by the free or iridian portion (*e e*) of the ciliary processes of the choroid, which can be easily turned back so as to expose the entire posterior surface. It presents extremely well marked radiated bands, which can be well seen, even before the choroid pigment is removed.

The aspect of the posterior surface of the iris differs essentially from that of the anterior surface: it is white and smooth, and resembles in many respects the internal surface of the choroid. Some anatomists are of opinion that the posterior surface of the iris is covered by the membrane of the aqueous humour. If such be the case, it is difficult to comprehend how that membrane is arranged with reference to the pigment.

Structure. The iris is three or four times as thick as the choroid; it diminishes in thickness from its outer to its inner border. Its real structure is but little understood. The old opinion of its muscularity, which was refuted by Weitbrecht and Demours, has been revived by M. Maunoir, who admits two sets of muscular fibres, viz. radiated fibres, which correspond to the external coloured ring, and circular fibres, which correspond to the internal coloured ring, and form a sort of sphincter around the pupil; but no circular fibres can be distinguished around the pupil. An appearance as if such were the case, is occasioned by a peculiar arrangement of the radiated fibres, which seem to bifurcate opposite the internal coloured ring, to interlace with each other, and then terminate abruptly around the pupil; so that the inner border of the iris, or the pupil, appears to be formed by the blunt extremities of these radiated fibres.

In the ox and the sheep, the iris has two very distinct sets of fibres — an anterior and circular layer, which occupies the whole of the anterior surface; and a posterior and radiated set of fibres, which converge from the outer to the inner border. The anterior set of fibres does not exist in the human subject.

Another and much more plausible opinion regarding the structure of the iris is, that it consists of a *vascular* or *erectile* texture.*

* A case is related of a young man who could produce contraction of the pupils by holding his breath.

[The muscularity of the fibres of the iris is now established beyond a doubt: the fibres of the iris of the pig are described by Schwann as being very minute, cylindrical, and not beaded; they therefore resemble the muscular fibres of organic life.]

If we examine an oblique section of the iris under a lens, we find indeed that it has an areolar spongy structure; and the extreme vascularity of this part also supports the same view.

Arteries of the iris. The *arteries* of the iris are principally derived from the two long ciliary arteries, which bifurcate and anastomose after they have reached the ciliary ligament, and form a vascular circle, which gives off radiated vessels that converge from the outer border of the iris towards the pupil. There are also some anastomotic arches near the pupil.

Veins of the iris. The *veins* of the iris are much more numerous than the arteries; they terminate in the venæ comites of the long ciliary arteries, and in the *vasa vorticosa.*

Nerves. The nerves of the iris, or *ciliary nerves* (*a a*, *fig.* 242.), are very large; as we have stated, they gain the ciliary circle, and then pass through it in great numbers, to enter the iris, and be distributed in its substance. Most of these nerves are given off from the ophthalmic ganglion: some of them are derived directly from the nasal nerve, which is a branch of the fifth cranial nerve.

The older anatomists distinguished two layers in the iris—one *anterior*, which they called the *membrane of the iris;* the other *posterior*, covered with pigment, which they called *membrana uvea.* By examining an oblique section of the iris with a lens, two layers may in fact be seen, separated by the spongy tissue of which I have spoken.

The Membrana Pupillaris.

Dissection. By opening the eye of the fœtus from behind, this vascular membrane may be easily seen through the vitreous body and the crystalline lens.

In the fœtus, the opening of the pupil is closed by a membrane, called the *membrana pupillaris*, which was discovered and very well described by Wachendorf, but more perfectly so by Haller and Soemmerring, and recently by M. Jules Cloquet. It may be seen about the third month of intra-uterine life, and generally disappears towards the seventh month. When persistent it may occasion congenital blindness. Wachendorf and Soemmerring have demonstrated the vessels of this membrane, which are continuous with those of the iris. During the existence of the membrana pupillaris, the membrane of the aqueous humour forms a shut sac. From the researches of M. Jules Cloquet concerning the pupillary membrane, it appears that it consists of two thin layers, between which the bloodvessels are arranged in loops; that the convexities of these loops are turned towards each other, but that the loops which approach each other from opposite sides do not anastomose together; that between these loops and towards the centre of the pupil, there is a small irregular portion of the membrane which is destitute of vessels, and is, therefore, weaker than any other part; that the formation of the pupil is effected by the rupture of this membrane, and that this rupture is occasioned by the retraction of the vascular loops which ultimately occupy the lesser border of the iris.

Uses of the iris. The iris regulates the quantity of light that is admitted into the interior of the eye. The contraction of the pupil is an active movement, and its dilatation is passive, facts which are opposed to the doctrine of its muscularity, but support the idea of its being a vascular and erectile structure.

It has been stated that the movements of the iris are intended to enable us to judge of the distance and size of objects, or rather to enable us to see objects at different distances: this is erroneous, for the pupil remains of the same size, under the action of a similar quantity of light, whether the object looked at be near or distant.* The effect of narcotics, and especially of bella-

* [The pupil certainly dilates in looking at distant objects, and contracts under the opposite

donna, either applied topically, or taken internally, in producing dilatation of the pupil, is one of the most curious facts concerning the iris. The direct action of the rays of light upon the iris has no influence upon the size of the pupil, the dimensions of which are altered either by the action of light upon the retina, or in consequence of a peculiar condition of the optic nerve or of the brain.

The Pigment of the Eye.

It has been stated that the external surface of the choroid and the internal surface of the sclerotic are coloured by a very thin layer of pigment; and also that the internal surface of the choroid is covered with a thicker layer, which is itself thickest on the fore part of that surface, near the ciliary body, between the great ciliary processes, and behind the iris. By means of this pigment the interior of the eye is converted into a true dark chamber. Still it may be asked, why the pigment is less abundant behind than in front.

The choroid pigment is not black, but of a very dark brown colour, like bistre, in this respect resembling the pigment of the skin of the negro; it consists of molecules or globules insoluble in water.

The pigment of the choroid of the iris is wanting in albinoes, as well as the cutaneous pigment. Both have the same chemical composition.*

In some animals the pigment of the eye has a metallic lustre, and an iridescent aspect in a great part of its extent.

The Retina.

The *retina* (*r*, *figs.* 241. 245.), counting from without inwards, is the third membrane of the eye; it is the immediate seat of vision, and is an essentially nervous membrane, situated within the choroid and the sclerotic. Its *external surface* (*r*, *fig.* 245.) corresponds to the choroid, from which it is separated by the pigment, which, in eyes that have undergone slight decomposition, forms an irregular layer upon it, like a web. Dr. Jacob (*Philosoph. Trans.* 1819) has described a serous membrane between the retina and the choroid, in the cavity of which a dropsical effusion may occur, and constitute what is called *posterior staphyloma of the eye.* M. Weber believes that this membrane is prolonged forwards to the circumference of the crystalline lens, and is then reflected over the posterior surface of the iris, where it becomes continuous with the membrane of the aqueous humour. I have not succeeded in demonstrating the membrane of Jacob. †

The *internal surface* (*r*, *fig*, 246.) of the retina is applied to the vitreous body, but does not adhere in the slightest degree to it.

The point at which the retina terminates in front is still regarded by most anatomists as undetermined. Several, with the older authors, describe it as extending to the circumference of the crystalline lens. Some entertain a modification of this opinion, believing that an extremely thin membrane is given off from the rim (*r′ r′*, *fig.* 241.) in which the retina seems to terminate, and that this membrane advances upon the inner surface of the ciliary body to the front of the capsule of the crystalline lens, to which it is attached. M. Dugès, in an excellent work upon the comparative anatomy of the organ of

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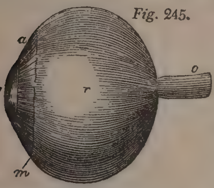
circumstances; but it is by no means certain that the adjustment of the eye to objects at different distances depends on these alterations in the condition of the iris.]

* [The pigment of the eye consists of nucleated cells containing the pigment granules; on the inner surface of the choroid these cells are flattened and hexagonal, and their sides fit accurately together, so as to present an appearance like mosaic work; on the back of the iris the cells are irregularly rounded. In albinoes the cells contain no coloured granules.]

† [If the posterior part of the sclerotic and choroid be carefully removed from a fresh eye (leaving the optic nerve untouched), and the eye be then macerated a few hours in water, portions of Jacob's membrane will either separate, or they can easily be separated from the outer surface of the retina.]

vision, expresses a somewhat different opinion: according to his view, the retina having reached the ciliary processes, divides into numerous tongues, each of which passes between two of the ciliary processes, and terminates by expanding upon the circumference of the crystalline lens. A careful examination has proved to me distinctly, that the retina terminates by a defined edge (margo dentatus; $r' r'$, *fig.* 241.; *m*, *fig.* 245.) at the posterior extremities of the ciliary processes of the vitreous body (*a*), to which processes it adheres rather firmly, though it can be sometimes separated from them without laceration.

Fig. 245.



Is the retina an expansion of the medullary part of the optic nerve, or is it a special organ continuous with that nerve? Although the former of these opinions appears more probable than the latter, still it is liable to objections. The optic nerve is constructed in a particular manner as it passes through the sclerotic, and the corresponding nervous substance is so arranged that pressure upon the nerve does not force the nervous substance into the interior of the eye, though pressure upon every other part of the nerve causes a white pulpy matter to exude from its divided surface.

The retina is semi-transparent, like a thin layer of opal: it scarcely holds together, and can be torn with the greatest facility. It does not appear to me to be thicker behind than in front.

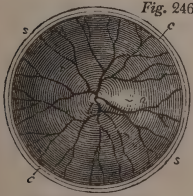
The radiated lines stated by several of the older anatomists, and also by M. Dugès, to exist in the retina, can only be distinguished behind at the entrance of the optic nerve. This radiated character was evident in the eye of an ox which I recently examined. The optic nerve divided into three thick diverging bundles which expanded into a layer; but this filamentous arrangement was soon succeeded by what appeared, at least, to be a pulpy structure.

Two layers are described in the retina — an *external*, which is pulpy and nervous; and an *internal*, which is vascular, and is formed by the ramifications of the arteria centralis retinæ; but this subdivision of the retina is purely fictitious. Soemmerring has given a good representation of the vascular network, which seems in some manner to support the nervous substance.

The foramen centrale, the fold, and the limbus luteus of the retina. Soemmerring was the first to describe in the retina a foramen (*foramen centrale*), which had escaped the researches of Ruysch, Zinn, and Haller, doubtless because it is concealed by the folds formed by the retina at this point.

It is doubtful whether these *folds* of the retina result from the collapsed condition of the eyeball, which necessarily follows the dissection required for the examination of its interior; or whether they are really part of its structure, and should be regarded as the vestige of the singular folds existing in different kinds of animals, and especially in birds, the visual powers of which are thereby greatly increased. However this may be, the foramen, which is always situated to the outer side of the entrance (*b*, *fig.* 246.) of the optic nerve, is surrounded with a zone of a canary-yellow colour: this is the *limbus luteus foraminis centralis* (*Soemmerring*), or the *yellow spot of Soemmerring* (*a*).

Fig. 246.



Interior of left eye.

The *foramen centrale* and the *limbus luteus* exist in man and the quadrumana only; that is to say, in those cases only in which the visual axes of the two eyes are parallel to each other, as in man.

I have not found that the yellow spot corresponds to the thickest part of the retina.

It should, moreover, be observed, that the foramen centrale, not the entrance of the optic nerve, corresponds to the antero-posterior axis of the globe of the eye, and is the true centre of the retina.

The uses of the central foramen and the yellow spot are not known.

The yellow spot does not exist in the fœtus.*

The Humours of the Eye.

The media through which the light passes in the eye, besides the transparent cornea already described, are the *vitreous body*, the *crystalline lens*, and the *aqueous humour.*

The Vitreous or Hyaloid Body.

The *vitreous* or *hyaloid body* (*v*, *figs.* 247, 248.) (from ὕαλος, glass), so called from its resemblance to glass, is an imperfectly spheroidal, and quite transparent mass, which occupies the posterior three-fourths (*v*, *fig.* 241.) of the globe of the eye; it is covered immediately by the retina (*v*, *fig.* 245.), which is simply in contact with it, and indirectly by the other coats of the back part of the eye, which are accurately moulded upon it. It presents a slight depression in front, for the reception of the posterior surface of the crystalline lens (*l*). The vitreous body and the crystalline lens together very nearly resemble in form the entire globe of the eye, the projection of the crystalline lens representing the prominence of the cornea (compare *figs.* 241. and 245.).

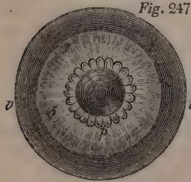
The vitreous body is composed of a liquid, named the *vitreous humour* †, and of the *hyaloid membrane.*

The *hyaloid membrane* (*h*, *fig.* 241.), which was first discovered by Fallopius, can be easily demonstrated by puncturing the vitreous body, and allowing the vitreous humour to escape. If it be then dipped in diluted nitric acid, the membrane will become opaque, and easily distinguishable. This membrane not only forms a general investment or capsule for the vitreous body, but gives off lamellar prolongations from its internal surface, which separate the vitreous humour into an irregular number of *compartments*, or *cells.* The existence of these cells can be easily proved by moving the vitreous body between the fingers: and if this body be frozen, their shape is shown by that of the masses of ice which may be taken from them.

It is generally admitted that all these cells communicate with each other; because, when one of them only is punctured, all the vitreous humour will gradually escape. Still I have several times observed that the eye did not collapse when a part of the vitreous body had escaped in the operation for extracting a cataract; this, however, might have depended upon any further escape being opposed by the approximation of the lips of the incision.

The manner in which the hyaloid membrane is arranged with reference to the crystalline lens, is still a disputed point. It is generally admitted that about a line from the margin of the crystalline lens, the hyaloid membrane divides into two layers, one of which passes behind (*h*, *fig.* 241.), and the other in front of the lens. The three-sided interval (*s s*) which exists all round the crystalline lens, and which has been described by François Petit, under the name of *canal godronné*, is formed between these two layers and the lens. This circular canal, or *canal of Petit*, can be very easily shown by blowing air into it (as in *p*, *fig.* 247.); it is then seen to be constricted at intervals,

Fig. 247.



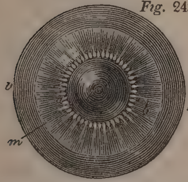
* [From recent researches, especially those of Valentin and Hanover, the following appears to be the minute structure of the retina: — 1. The membrane of Jacob consists of minute cylindrical or prismatic bodies, placed closely together, and perpendicularly to the surface of the membrane; among these are somewhat larger bodies, "coni gemini," which might be compared in shape to two cylinders applied to each other lengthwise. Both kinds of bodies are attached by one extremity to the inner surface of the choroid, being received into exceedingly minute sheaths, which rise from the surface of the pigment cells. 2. The filaments of the optic nerve spread out on the inner surface of this structure, and according to Valentin, have a plexiform arrangement, but their mode of termination seems doubtful. This nervous expansion is covered on its outer and also on its inner surface by a layer of ganglionic globules.]

† [The vitreous humour, according to Berzelius, contains 98·4 per cent. of water; its solid matter consists of albumen, extractive matter, and chloride of sodium.]

as if by small folds or bands, so that it presents a knotted or plaited appearance. Other anatomists, on the contrary, state that the hyaloid membrane does not split into two layers, but passes altogether behind the crystalline lens, in order to cover the front of the vitreous body. It is certain that a circular layer, having the form of a radiated crown, is given off from the anterior part of the hyaloid membrane; this circular radiated disk was described by Petit and Camper, but it is called the *corona ciliaris*, or the *zonula Zinni*: it corresponds accurately to the ciliary processes and ciliary body of the choroid coat.

The *ciliary zone of Zinn* (*a*, *fig.* 245.; *b*, *figs.* 247, 248.), or *the ciliary processes of the vitreous body*, can be seen through that transparent body (*d*, *fig.* 241.) when the several coats are removed from the back part of the globe of the eye; it is completely exposed to view when the choroid coat and the iris are separated from the vitreous body (*fig.* 248.). It is this structure which constitutes the beautiful radiated crown situated in front of the vitreous body around the crystalline lens, and which extends considerably beyond the ciliary body of the choroid; it consists of alternate black and transparent rays, and is generally regarded as a reverse impression of the ciliary processes of the choroid. The ciliary processes of the vitreous body correspond to the black lines, and the intervals between the processes to the transparent rays.

Fig. 248.



The ciliary processes of the vitreous body are not so thick as those of the choroid; but the folds of which they consist commence further back than the ciliary processes of the choroid, so that the radiated disc formed by them is larger than that formed by the processes of the choroid. These folds of the vitreous body have the same spongy and jagged appearance as those of the choroid: they have no free portion, or rather that part of the zone of Zinn (*a*, *fig.* 248.) which corresponds to the free portion of the ciliary processes of the choroid, is applied to the crystalline lens.

The ciliary processes of the choroid and those of the vitreous body are so arranged, that those of the one are received in the intervals between those of the other. It appears to me difficult to determine whether they are simply applied to each other, or whether their structure is continuous. However, on examining these parts through a lens whilst they are being separated, it has appeared to me that a sort of cellular structure was lacerated, and that the black pigment, which had been hitherto confined, escaped together with a little fluid. M. Ribes believes that during this separation, some shreds of the hyaloid membrane are drawn away with the ciliary processes of the choroid.

The inner border (*a*) of the ciliary zone of Zinn is in contact with the margin of the crystalline lens (*l*), and adheres rather firmly to it. Around the outer border, which extends beyond the ciliary body of the choroid, are found the origins of certain radiated folds (*b*), which form, as it were, the commencements of the ciliary processes. This border adheres to the anterior margin of the retina (*m*, *fig.* 245.), which appears to me to be thickened and slightly uneven in this situation, and not to be continuous with the hyaloid membrane.

From what has been stated, it follows that the canal of Petit is formed between the hyaloid membrane and the zone of Zinn, and that the crystalline lens is fixed by this zone to the anterior margin of the vitreous body; that the anterior surface of the crystalline lens is not covered by a prolongation of the hyaloid membrane, besides its own capsule; and that the retina does not reach as far as the margin of the crystalline lens.

M. Jules Cloquet has described under the name of the *hyaloid canal* a cylindrical passage, which is formed by the reflection of the hyaloid membrane into the interior of the vitreous body around the nutritious artery of the lens,

and which, like that artery, traverses the vitreous body from behind forwards. I have never been able to see this canal.

No vessels have been demonstrated in the hyaloid membrane; it does not receive any from the retina, and yet we cannot doubt that it is provided with them. Although the structure of the ciliary processes of the vitreous body is little known, yet, as it is probable that it is similar to that of the ciliary processes of the choroid, and therefore essentially vascular, it may be as stated by M. Ribes, that the materials for the formation and nutrition of the lens and of the ciliary processes of the vitreous body are conveyed to both of these parts through the vascular ciliary processes of the choroid.

The Crystalline Lens and its Capsule.

The *crystalline lens* (*l*, *figs.* 241. 244, 245. 248.) is a transparent body, having the form of a lens, as its name implies; it is situated at the junction of the posterior three fourths with the anterior fourth of the globe of the eye, and is placed between the vitreous body, which is behind, and the aqueous humour, which is in front (see *fig.* 241.).

Its axis corresponds to the centre of the pupil.

It is shaped like a double convex lens, the posterior surface of which is more convex than the anterior. From some very exact and minute investigations which have been made upon this point by François Petit and others, it appears that both the relative and the absolute convexity of the two surfaces of the crystalline lens are subject to great varieties in different individuals; that, in general, the posterior convexity forms part of a circle from four to five lines in diameter, while the anterior forms part of one from six to nine lines in diameter. In some subjects the degree of curvature of the two surfaces of the crystalline lens is almost equal. In the fœtus the crystalline lens approaches the spheroidal form, which is that which it has in fishes.

The *anterior surface* of the crystalline lens corresponds to the iris, from which it is separated by the aqueous humour. It has been incorrectly stated by Winslow that the crystalline lens pushes the iris forwards: there is a space between the crystalline lens and the iris which constitutes the posterior chamber of the eye. The anterior surface of the lens may be seen through the pupil, so that slight shades of difference in the colour of the lens may be detected. When the pupil is very much dilated, the anterior surface of the lens is entirely exposed.

Its *posterior surface* is in relation with the vitreous body, which is depressed so as to receive it. This surface does not adhere to the hyaloid membrane. When dissecting a subject of twenty-seven years of age who had suffered with hydrophthalmia in both eyes, M. Ribes found about six grains of a limpid fluid between the hyaloid membrane and the crystalline lens; so that the space occupied by this fluid might have been taken for a third chamber.

The margin of the lens (*l*, *fig.* 248.) is set (like the stone of a brooch) in the ciliary processes (*a*) of the vitreous body, which cover and adhere to the fore part of that margin, so that the lens is kept firmly in its place. Its margin is surrounded by the canal of Petit (*fig.* 247.).

The crystalline lens presents different shades of colour at different periods of life. It is reddish in the fœtus, but is perfectly transparent after birth; in the adult, it becomes slightly opaline at the centre; in the aged, it acquires a yellowish opacity, which approaches somewhat to the colour of amber or topaz. Morbid opacity of the lens constitutes lenticular cataract.

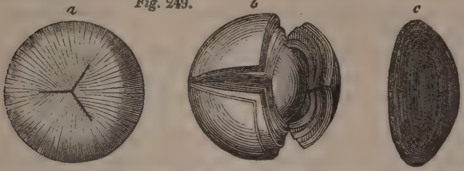
The crystalline lens consists of a *capsule* and of a *proper substance* inclosed within it.

The substance of the crystalline lens. When stripped of its capsule the crystalline lens is found to have three degrees of consistence, at different parts: thus, at its surface, it is almost of a liquid softness; below this, it is soft and gelatinous, and may be crushed by the finger — this is the *cortical layer*; and,

lastly, it is hard in the centre which is called the *nucleus*, and closely resembles a mass of gum arabic. The most superficial and fluid layers constitute the *liquor Morgagni.*

The substance of the crystalline lens consists of concentric layers (*b c, fig.* 249.) which can be very easily demonstrated, even without any previous preparation, but are rendered most distinct by boiling, or immersion in a diluted acid. The crystalline lens then separates into superimposed laminæ or scales, like the bulb of the onion.

Fig. 249.



The different degrees of consistence observed in the substance of the lens do not depend upon differences in nature, but upon mere modifications. When hardened by an acid, the structure of the lens is exactly the same throughout: even the liquor Morgagni appears to become laminated.

Each of these concentric laminæ is itself composed of radiated fibres (*a, fig.* 249.) which can be readily seen without dissection, by placing one of them upon a black surface and examining it through a lens, or even by a strong light.

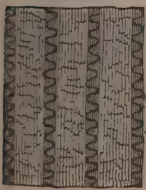
Lastly, the crystalline lens, when boiled or submitted to the action of an acid, splits into three, four, or even a greater number of triangular segments (*a b*), all of which unite by their summits at the centre of the lens, so that its anterior and posterior surfaces have a stellate appearance.* Pathologists have successfully applied this anatomical fact to the explanation of the stellate forms of cataract in which the opacity branches out in three or more directions.

What is the nature of the crystalline lens? Is it the product of a secretion? or is it an organised structure? M. Dugès has recently supported by his authority and by additional facts the opinion of Dr. Young, who believed that the crystalline lens is not only an active organised structure, supplied with vessels and veins, but that it is even muscular and possessed of contractility, so as to be able of itself to increase or diminish its curvatures and its density, thus endowing the eye with the power of adjusting itself to the different distances of the objects to be seen. The substance of the laminæ of the crystalline lens has indeed a linear structure; but it does not at all resemble muscular tissue, either in its consistence, or in its regularly stratified character. I conceive, therefore, that I am warranted in regarding the superimposed layers of the crystalline lens as the solidified product of a secretion formed by its capsule.†

The *capsule of the crystalline lens* (*t, fig.* 241.) is accurately fitted to the lens itself; in the healthy state it is transparent, but may become opaque, and thus constitute a membranous or capsular cataract.

Its external surface is free in front, where it is bathed by the aqueous humour: it is merely in contact with the hyaloid membrane behind, but its cir-

Fig. 250.



* See note *infrà*.

† [The lines indicating the divisions between the triangular segments of the lens (*a, fig.* 249.) are called *septa;* the septa of the anterior surface are placed opposite the intervals between the septa of the posterior surface. The fibres of which the laminæ are composed have a linear arrangement, and, as discovered by Sir D. Brewster, are fitted into each other by indented margins (*fig.* 250.). Schwann has shown that these fibres are developed from rounded nucleated cells, which become elongated into fibres, the margins of which subsequently become dentated; the lens, therefore, resembles some other non-vascular parts (as the horny tissues) in its mode of growth. It consists, according to Berzelius, of 58·0 per cent. of water, 3·7 of extractive and salts, 2·4 of membrane, and 35·9 of a peculiar substance, which, except in its colour, resembles the colouring matter of the blood.]

cumference adheres intimately to that membrane, or rather to the ciliary zone of Zinn.

Its internal surface does not appear in the slightest degree adherent to the lens. If an incision be made into this capsule in the living subject, the lens is forced out merely by the tonicity of the coats of the eye. The anterior segment of the capsule is twice as thick as the posterior: it might be compared to a layer of the cornea.*

It receives bloodvessels derived from the arteria centralis retinæ.† These vessels, according to Meckel, are distributed only upon the posterior half of the capsule; those which belong to the anterior half arise from the vessels of the ciliary processes.

Some anatomists believe that these vessels send ramifications between the different concentric laminæ of the crystalline lens, for its nutrition; but I am not aware that they have ever been demonstrated.

No nerves have been discovered in the crystalline lens. M. Dugès believes that the retina gives off some nervous filaments which reach as far as the lens, and spread out upon its capsule; but after the most careful examination I am convinced that such is not the case.

The Aqueous Humour and its Membrane.

The term *aqueous humour* is applied to a perfectly limpid and transparent fluid, which occupies the two chambers of the eye. These two chambers, which have been correctly understood only since the discovery of the true seat of cataract in the crystalline lens, correspond to that small portion of the cavity of the eye which is situated between the cornea and the lens (see *fig.* 241.). The space between these two parts is divided unequally by the iris (*i*) into two chambers — an anterior and larger, which is called the *anterior chamber*; and a posterior and smaller, named the *posterior chamber*. These two chambers communicate through the pupil (*p*). The existence of the posterior chamber was long disputed, but it may easily be proved by freezing the eye: and by the same experiment we may obtain an approximation to the relative capacity of the two chambers, which will be found as 3 to 1, the anterior being decidedly the larger.

The total quantity of the aqueous humour is about five grains; 100 parts of it are found to contain 98·1 of water, with traces of albumen and chloride of sodium.

The membrane of the aqueous humour. It is now generally admitted that the aqueous humour is secreted by a special membrane, called the *membrane of the aqueous humour*, or *membrane of Demours*, although it had been previously described by Zinn and Descemet. This membrane, according to Demours, lines the posterior surface of the cornea (*m*, *fig.* 241.), and is reflected upon the front of the iris. At this point, according to most anatomists, it is lost, and cannot be traced to the pupil; but, according to others, it proceeds as far as the pupil, and there terminates: and, lastly, some believe that it is reflected through the pupil, in order to cover the posterior surface of the iris, where it retains the pigment in its situation.

It is easy to detach a tolerably thick and strong layer, of a cartilaginous aspect, from the posterior surface of the cornea, either after long-continued maceration, or after slight boiling; but it is not shown that this is any thing more than the posterior layer of the cornea, which it resembles in appearance.

* According to M. Ribes, whom I always have pleasure in quoting, because his researches are worthy of every confidence, " by examining the internal surface of the crystalline capsule in a good light, and with a good lens, a series of transverse fissures are observed around its entire circumference, where the anterior and posterior segments of the capsule unite. I could never satisfy myself whether these fissures corresponded to the ciliary processes of the vitreous body, or to the villous fringes of the ciliary processes of the choroid."

† Vide fig. v. pl. 6. of Soemmerring's *Icones Oculi Humani.*

It is only from analogy that the existence of the membrane of the aqueous humour can be admitted.

We cannot demonstrate anatomically its reflection upon the outer border of the iris; and, moreover, it is certain that it does not exist upon either surface of that membrane.

According to M. Ribes the aqueous humour is supplied by the vitreous body, and is poured into the posterior chamber by the canals, said by him to exist in the substance of the ciliary processes of the vitreous body. This opinion is founded, 1. upon an experiment, which consists in carefully removing the cornea, and suspending the eye by the optic nerve, when the vitreous humour will exude from the wound of the cornea, so that in less than twenty-four hours two thirds of that body will have escaped; and 2. upon the observation of cases of imperfect iris, in which, according to M. Ribes, the aqueous humour is contained entirely in the posterior chamber. He believes that the free portion of the vitreous ciliary body has the power of absorbing this liquid.

M. Dugès adopts the following modification of this opinion: — the canal of Petit, according to him, is divided into as many compartments as there are ciliary processes. It resembles, therefore, a collection of short canals directed from before backwards, rather than a single circular canal; these short canals communicate behind with the vitreous body, and open in front by certain slits or perforations existing in the zone of Zinn, which enable the aqueous humour secreted by the vitreous body to escape in front of the crystalline lens.

Haller has stated all the opinions which have been entertained regarding the production of the aqueous humour, which has been said to be secreted by the vitreous body, as believed by MM. Ribes and Dugès, by the ciliary processes, by the choroid, by the iris, and, lastly, by certain special ducts proceeding from without the eye, and perforating the sclerotic at its junction with the cornea.

The Vessels and Nerves of the Eye.

The *arteries* of the eye are the following: a considerable number of *short posterior ciliary arteries*, which surround the optic nerve, perforate the sclerotic near it, and ramify in the choroid, in the ciliary processes, and in the iris; the *anterior short ciliary*, which perforate the anterior part of the sclerotic, and are distributed to the iris; the *long ciliary arteries*, two in number, which run between the sclerotic and the choroid, as far as the outer border of the iris, and then bifurcating and curving inwards, anastomose with each other around that border. From the vascular circle thus formed most of the vessels of the iris are given off. The *central artery of the retina* (*arteria centralis retinæ*) enters the globe of the eye through the centre of the optic nerve (at the porus opticus, *b*, *fig.* 246.), and sending off a branch to the crystalline lens, which traverses the vitreous body from behind forwards, covers the internal surface of the retina with its other ramifications.

The *veins* correspond to the arteries, but are much more numerous. The posterior, or short ciliary veins, form vortices or whorls in the choroid, and are hence called *vasa vorticosa* (*v*, *fig.* 244.). All the veins of the globe of the eye open into the ophthalmic and angular veins.

The *nerves* of the eye consist of a special nerve, called the *optic nerve*, the origin, course, and structure of which will be described hereafter (see Cranial Nerves); and, secondly, of the *ciliary nerves*, which are derived from the fifth nerve, either directly from its nasal branch, or indirectly from the ophthalmic ganglion. These nerves (*a a*, *fig.* 242.) are distributed to the ciliary ligament and to the iris.

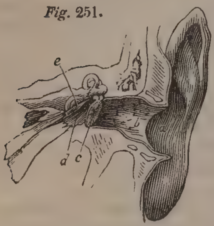
The Organ of Hearing.

Hearing is that sense by which we perceive the vibrations of the air, which produce *sound*.

The organ of hearing is not situated in the face, like those of the other senses, but is contained in the substance of the base of the cranium, in the petrous portion of the temporal bone, its deep situation preserving it from external violence: it is composed essentially of a membranous and nervous apparatus contained in an extremely complicated osseous cavity, named the *labyrinth*, or *internal ear*.

The labyrinth (*f*, *fig.* 251.) communicates with the exterior by means of an acoustic trumpet, formed by the *auricle*, or *pinna* (*a*), and external *auditory meatus* (*b*), and named the *external ear*, which may be regarded as an apparatus for collecting sonorous undulations.

Fig. 251.



The term *middle ear*, or *tympanum*, is applied to a cavity (*d*) which is placed between the labyrinth and the external ear, and may be considered as an apparatus for modifying sounds, the intensity of which is increased or diminished by it, according as they happen to be weak or loud.* It follows, therefore, that the ear is formed by a succession of cavities, which, proceeding from without inwards, are, the external ear, consisting of the auricle and external auditory meatus, of the middle ear, or tympanum, and of the internal ear, or labyrinth. I shall describe the ear in this order, and shall thus proceed from the less to the more complicated parts of this organ.

The External Ear.

The *external ear* resembles a funnel or ear-trumpet, the expanded part of which represents the *auricle*, whilst the contracted portion corresponds to the external auditory meatus.†

The Auricle.

The *auricle* of the ear (*auricula*, *pinna*), commonly called *the ear*, is placed at the side of the head, behind the articulation of the lower jaw, and in front of the mastoid process; it is an oval elastic lamina, folded in various ways upon itself, and having an undulated surface.

The auricle or pinna is free above, behind, and below, but is so firmly attached in front and on the inner side, that the two ears can support the weight of the entire body.

The individual varieties in the shape, direction, prominence, and size of the auricle are generally known. Of these varieties, some are congenital, and others acquired. Among the latter should be noticed the effects produced by the habit of confining the entire ear more or less closely by the head-dress. The direction or prominence of the auricle is not without some influence upon hearing; the perfection of which sense, according to Mr. Buchanan, depends on the kind of angle formed by the auricle with the side of the face, and which should be from 25° to 30°.

The *internal* or *mastoid surface* of the auricle presents certain eminences and depressions which correspond inversely with those on its external surface.

The *external surface* is remarkable for the alternate ridges and depressions

* M. Richerand (*Elemens de Physiologie*, first edit.) has drawn an excellent comparison between the uses of the tympanum in hearing, and those of the iris in vision.

† The external ear, properly speaking, only exists in mammalia; and even among mammalia, those which do not live constantly in the air, are not provided with it.

observed upon it: at its centre, but somewhat nearer to the lower than the upper part, we find the *concha* (*a*, *fig.* 252.), a funnel-shaped excavation, the form and expansion of which are familiar to all, and at the fore-part of the bottom of which is found the orifice of the external auditory meatus.

Fig. 252.

The concha is bounded in front by the *tragus* (*b*), a triangular process, the adherent base of which is turned forwards and inwards, whilst its free apex is directed backwards and outwards: it advances like a lid over the orifice of the external auditory meatus, which is completely closed by its depression. The posterior surface of the tragus, which forms part of the concha, is covered with stiff hairs, especially in old subjects; whence its name of *tragus*, from *τράγος*, a goat. The use of these hairs is to arrest any small particles that are floating in the air.

Behind and below, that is, opposite the tragus, the concha is bounded by the *anti-tragus* (*c*), a triangular tongue, which is smaller than the tragus, and is separated from it by a wide, deep, and rounded notch, named the *notch of the concha* (*incisura tragica*).

Behind and above, the concha is bounded by the *anti-helix* (*e*), a curved fold, which commences above the anti-tragus, being separated from that part by a slight depression, passes upwards and forwards, bifurcates, and then ends in the groove of the helix. The superior branch of the bifurcation of the anti-helix is broad and smooth, whilst the inferior is sharp; between them is situated a slight depression, called the *scaphoid*, or *navicular fossa*, but which would be more correctly named the *fossa of the anti-helix* (*f*).

The term *helix* (ἕλιξ, a roll; from ἑλίσσω, to roll around) is applied to a curved fold (*g g*) which forms the external border of the auricle: it commences in the cavity of the concha, which it divides into two unequal parts, one superior and narrow, the other inferior and broader; gradually increasing in size, it then passes upwards and forwards above the external meatus, then above the tragus, from which it is separated by a very distinct furrow: it next runs directly upwards, curves backwards, descends to form the posterior margin of the auricle, and terminates by becoming continuous with the anti-helix in front, and with the *lobule* (*l*) behind.

The groove or *furrow of the helix* is the groove (*i*) which surrounds the helix and separates it from the anti-helix.

The *lobule* occupies the lower or small extremity of the auricle, from the rest of which it is distinguished by its softness; it is surmounted by the tragus in front, by the anti-tragus behind, and by the notch of the concha in the middle. The lobule of the ear varies exceedingly in size in different individuals, and is the part to which ear-rings are generally appended.

The structure of the auricle. The *cartilage* of the ear (*figs.* 253, 253*.) constitutes the framework of the auricle, in a great measure determines its shape, and is the cause of its pliability and elasticity.

Fig. 253.

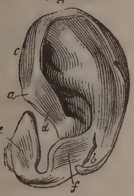
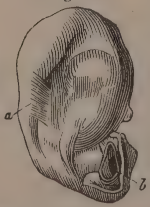


Fig. 253*.



When the skin is removed from it, this cartilage, therefore, presents certain eminences and depressions, corresponding, with some exceptions, to those already described as existing upon the surface of the auricle. The cartilage of the ear has no part corresponding with the lobule: again, the cartilaginous fold which constitutes the helix terminates at the middle of the concha, from whence it is continued by a fold of skin, which, moreover, covers it throughout and increases its prominence. Upon the cartilage of the auricle we also observe the following parts:— 1. A mammillated eminence (*a*, *fig.* 253.), called

the *process of the helix*: it is of considerable size, is very dense, and arises from the anterior margin of the helix, above the tragus. This process gives attachment to a ligament.

2. A tail-shaped tongue of cartilage (*b*), separated from that of the anti-tragus and concha by a very long fissure, which is occupied by ligamentous fibres. This tongue is formed by the united ends of the helix and anti-helix, and is very thick and dense; it may be called the *caudal extremity of the helix and anti-helix*; it supports the base of the lobule.

3. A well-marked thickening, situated opposite the concha, and characterised by a dead white colour. This thickening occupies a vertically elongated portion of the mastoid surface of the concha, and terminates at the lower part of the auricular cartilage: it seems to be intended to preserve the form of the concha, which cannot be flattened unless this thickened portion of the cartilage is first divided. Several fissures or notches are also found in the cartilage of the ear, which is thus imperfectly divided into several pieces that are movable upon each other, and united together by ligaments. The principal fissure, independently of that already described as existing between the anti-tragus and the caudal extremity of the helix and anti-helix, are, a small vertical fissure upon the anterior margin of the helix; another vertical fissure upon the tragus; several irregular notches in the helix; and, lastly, a much more important fissure, to which I shall have to allude in describing the external auditory meatus. It is situated between the helix and the tragus, and is prolonged upon the outer half of the orifice of that meatus.

The *skin* of the auricle is remarkable for its thinness and transparency: hence the subcutaneous vascular network can be seen through it without dissection; it is no less remarkable for its tension and its close adhesion to the cartilage, upon which it is moulded, so as accurately to reveal its form. The portion of skin which covers the concha is especially remarkable for its great tenuity and intimate adhesion to the cartilage.

The skin upon the free border of the auricle adheres but slightly to and projects beyond the helix; the same fold of skin, when doubled upon itself and prolonged below the helix, constitutes the lobule, which, together with the adjacent part of the free border of the auricle, is nothing more than a duplicature of the skin, containing some soft fat. A small quantity of fat is formed around the entire circumference of the auricle, but none exists in other situations.

The skin of the ear is provided with sebaceous follicles, which can be easily shown by maceration, after the method employed by Soemmerring, and which are most numerous in the concha and the scaphoid fossa.

The *ligaments* of the auricle are divided into the intrinsic and the extrinsic ligaments.

The *extrinsic ligaments* are, the *posterior ligament*, which is a thick, tendinous layer, extending from the concha to the mastoid process; the *anterior ligament*, which is a triangular, very broad, and very strong ligament, arising from the process of the helix and the adjacent part of the border of the helix, and terminating at the zygomatic arch, where it is blended with the superficial temporal fascia; and, lastly, the *ligament of the tragus*, which is very strong, and extends from the tragus to the adjacent part of the zygomatic arch.

The *intrinsic ligaments*, the object of which is to keep the cartilage of the auricle folded upon itself, are, the ligament which keeps the caudal extremity of the helix applied to the concha; the very strong ligament which extends from the tragus to the helix, and unites the outer half of the auditory meatus to the cartilage of the auricle; some very strong bundles, which are situated upon the mastoid surface of the auricle, and are intended to preserve its convolutions, for when they are divided the auricle may be unfolded; lastly, those most remarkable ligamentous bundles, which occupy the fold presented by the inferior branch of the bifurcation of the anti-helix.

The three *extrinsic muscles* of the ear, which exist in a rudimentary con-

dition in the human subject, but are so highly developed in timid animals, are intended to move the auricle as a whole. (See MYOLOGY.)

The *intrinsic muscles* move the different parts of the auricular cartilage upon each other. Like the extrinsic, they are quite rudimentary. There is no difference in their size in savage and civilised races. They are five in number, four of them being situated on the concave, and one only on the convex, or mastoid surface of the auricle.

The *great muscle of the helix* (helicis major, *c*, *fig.* 253.) is situated vertically upon the anterior part of the helix, near the tragus; it is a narrow, oblong tongue, fleshy in the middle, and tendinous at its extremities; its fibres are vertical.

The *small muscle of the helix* (helicis minor, *d*), the smallest of the intrinsic muscles of the ear, lies upon that portion of the helix which divides the concha into two parts.

The *muscle of the tragus* (tragicus, *e*), is a broad band, lying upon the external surface of the tragus; its fibres are directed vertically.

The *muscle of the anti-tragus* (anti-tragicus, *f*), is a tongue-like bundle, which covers the external surface of the anti-tragus, and is inserted by a tendon to the upper part of the caudal extremity of the helix. Its use may be to move this caudal extremity upon the anti-tragus.

The fifth is the *transverse muscle* (transversus auriculæ, *a*, *fig.* 253*.), which is situated on the mastoid surface of the auricle. According to Soemmerring, it consists of a transverse layer of fibres of unequal length, which spread out in a semicircular form from the convexity of the concha to the ridge, corresponding to the groove of the helix. I doubt the muscularity of these fibres. which I am inclined to regard as constituting an intrinsic ligament intended to preserve the fold of that portion of the anti-helix by which the concha is bounded behind and above.

The *arteries* of the auricle are the posterior auricular, a remarkable branch of which passes through the cartilage, between the caudal extremity of the helix and the concha, so as to ramify in the cavity of the concha. All the branches of the posterior auricular arteries turn over the free border of the helix, so as to reach the concave surface of the auricle. The anterior auricular arteries arise from the external carotid and the temporal, and divide into inferior branches or arteries of the lobule, and ascending branches. The *veins* have the same names and follow the same course as the arteries.

The *nerves of the auricle* are derived from the auricular branch of the cervical plexus; three or four of them ramify upon the internal surface of the auricle. A remarkable branch perforates the cartilage between the anti-tragus and the caudal extremity of the helix, and is distributed to the skin which lines the concha.*

The External Auditory Meatus.

The *external auditory meatus* (*b*, *fig.* 251.) is a partly cartilaginous, and partly osseous canal, extending from the concha (*a*) to the membrane of the tympanum (*c*). It forms the narrow portion of the ear-trumpet represented by the external ear.

It is about an inch in *length.* Its section represents an ellipse, of which the longest diameter is vertical. Its direction is transverse, and it describes a very slight curve, having its convexity turned upwards. Moreover, near its external orifice, it is bent at an angle which projects upwards, and hence it is necessary to draw the auricle upwards and backwards, if we wish to examine the bottom of the external auditory meatus.

The external meatus is in relation with the temporo-maxillary articulation in front, with the mastoid process behind, and with the parotid gland below.

* [The auricle also receives twigs from the *posterior auricular* branch of the facial nerve, from the auriculo-temporal branch of the inferior maxillary division of the fifth nerve, and from a small branch of the pneumogastric nerve. See description of those nerves.]

Its *external orifice*, which is vertically oblong, more or less widened out in different individuals, and covered with hairs in old age, occupies the anterior and inferior part of the concha behind the tragus, which serves as a lid for it. It is bounded behind by a sort of *semilunar ridge*, which projects more or less forwards, in different individuals, so as to contract its orifice to a greater or less extent. In front of the auditory meatus there is an excavation or fossa concealed by the tragus, and named the *tragic fossa of the concha;* it forms as it were the vestibule of the meatus.

The *internal orifice* of the auditory meatus is circular: it is directed very obliquely downwards and inwards, and is closed by the membrana tympani.

Structure. The auditory meatus consists of an osseous portion and of a *cartilaginous and fibrous part.*

The *osseous portion* has been already described with the temporal bone, as the *external auditory meatus.* It is wanting in the fœtus, and in the new-born infant, in which its place is supplied by the *tympanic ring* or *circle.* We have stated that, in the adult, this ring forms an osseous lamina distinct from the rest of the temporal bone, that it rests behind upon the mastoid and styloid processes, for the latter of which it forms the vaginal process, and that it is separated in front from the auricular portion of the glenoid cavity by the fissure of Glasserius; this lamina forms both the anterior and inferior walls of the auditory meatus and cavity of the tympanum.

The *cartilaginous and fibrous portion* forms the outer half of the external auditory meatus, and may be separated from the cartilage of the auricle by a careful dissection. If an incision be made over the semilunar ridge which constitutes the outer border of the orifice of the auditory meatus, it will be seen that this ridge is formed by the juxtaposition of two cartilaginous borders, one of which belongs to the concha, and the other to the auricle, and which are united by fibrous tissue. If the dissection be continued between the tragus and the corresponding part of the helix, the auricle may be separated from the auditory meatus, excepting below, where their continuity is established by means of a tongue or isthmus of cartilage.

The tragus belongs essentially to the auditory meatus, the cartilage of that canal being merely a prolongation of the tragus folded upon itself (see *b, fig.* 253*.) so as to form the lower two thirds or three fourths of a cylinder. The inner end of this imperfect cylinder is attached to the rough external rim of the osseous portion of the meatus, by means of a fibrous tissue, which extends further above and behind than below and in front, and which gives the cartilage a great degree of mobility; there is a thick prolongation or process at the lower and anterior part of the inner end of the cartilage of the meatus.

The *fibrous portion* of the auditory meatus forms the upper third or fourth of that canal, and also fills up the large notch in the inner end of the cartaliginous portion.

Near the tragus there are two or three fissures or divisions in this cartilage, named the *fissures of Santorini*, which give it some resemblance to the rings of the trachea: these fissures are at right angles to the length of the canal, and are filled up with a fibrous tissue, which some anatomists have conceived to be mixed with muscular fibres, or to consist entirely of muscular fibres intended to move the small and partially separated portions of the cartilage. It is evident that the mode in which the partly cartilaginous and partly fibrous portion is united with the osseous portion of the canal, and also the existence of the fissures just described, have reference to the mobility of the entire canal.

The internal surface of the auditory meatus is lined by a prolongation of the *skin*, which is remarkable for its extreme thinness. It becomes thinner and thinner in advancing from the orifice to the bottom of the meatus; and the fineness and extreme delicacy of that portion of the skin, which corresponds to the osseous part of the meatus, deserves special attention. The skin of the meatus is also characterised by being covered in all parts with fine downy hairs, a fact which proves that it is of a cutaneous structure, and not a mucous mem-

brane. In old subjects, there are some tolerably long hairs at the commencement of the auditory meatus, as well as upon the internal surface of the tragus; they prevent the entrance of dust and insects, which moreover get involved in the ceruminous secretion.

The skin of the meatus is further characterised by the presence of a number of sebaceous follicles, or glands, called the *ceruminous glands* *, the orifices of which are visible to the naked eye, and give the skin an areolar appearance. These small glands occupy the entire inner surface of the cartilaginous and fibrous portions of the auditory meatus: from their yellowish brown colour they can be readily seen in oblique sections of the skin. They secrete a rather thick unctuous substance, resembling wax, whence it is called *cerumen* (*cera*, wax). It is very bitter, and is partially soluble in water, with which it forms an emulsion which leaves a greasy stain upon paper; it sometimes becomes exceedingly hard from remaining long in the passage, and then acts as a mechanical cause of deafness. By analysis, this substance, according to Berzelius, yields a fatty oil, an albuminous substance, and a colouring matter, and, according to Rudolphi, a bitter principle like that of the bile. Nature intended, says Soemmerring, that there should be a sufficient quantity of cerumen, not only to keep out insects, but also to diminish the intensity of sonorous vibrations. It is therefore a bad habit to remove it artificially unless there be an abnormal accumulation of this substance.

The Middle Ear, or Tympanum.

Dissection. The cavity of the tympanum may be laid open either from its external wall, by removing the membrana tympani, or from its upper wall, by cutting away the anterior part of the base of the petrous portion of the temporal bone with a strong scalpel; the situation in which this may be done is indicated by a fissure or rather a suture, which exists between the petrous and squamous portions; lastly, the tympanum may be opened from its lower wall, by breaking down the osseous plate of the auditory meatus.

In order to show all the parts contained in the cavity of the tympanum, several specimens should be prepared in different ways. It is of importance, moreover, to study the ear in the temporal bones of the adult subject and the fœtus, as well in macerated specimens as in such as have been dried without previous maceration.

The *tympanum*, *tympanic cavity*, or *drum* of the ear (*tympanum*, a drum; *d*, *fig.* 251.), is a cavity situated between the external auditory meatus (*b*) and the labyrinth or internal ear (*f*); it communicates with the pharynx, and consequently with the air passages, by means of the Eustachian tube (*e*, *fig.* 255.); it is prolonged into the mastoid process, by means of the mastoid cells (*c*), and it is traversed by a chain of small bones (1, 2, 3), named the *ossicula auditûs*.

The tympanum is placed in the anterior part of the base of the petrous portion of the temporal bone, above the osseous lamina of the external meatus, and in front of the mastoid process; it is directly continuous with the osseous portion of the Eustachian tube, of which it seems only to be a dilatation.

From its *form*, which is otherwise irregular, or rather from the two dry membranes formed upon its opposite walls, it has been compared to a military drum; it is flattened from without inwards, so that its transverse diameter is the *shortest*. It presents for our consideration an *internal* and an *external wall*, and a circumference.

The external wall of the tympanum. This wall is formed by the *membrana tympani*, and by that portion of the temporal bone, in which the membrane is fitted. This portion of the temporal bone is a compact lamina, which is flat in the human subject, but extremely prominent in some animals.

* [The ceruminous glands consist of a long convoluted tube, closed at one end, and opening by the other upon the internal surface of the meatus.]

The *membrana tympani* (*c, fig.* 251.) is a nearly circular, semi-transparent membranous septum, dry-looking like parchment, and vibratile; it is situated between the external auditory meatus, at the bottom of which it may be seen in the living subject, and the cavity of the tympanum. It is *directed* very obliquely downwards and inwards; so that, instead of passing perpendicularly across the auditory meatus, it is continuous, at a very slight angle, with the upper wall of that canal. In consequence of this obliquity, the membrana tympani unites with the lower wall of the meatus, at an angle of about 45°, and the meatus itself terminates in such a manner that its lower wall is much longer than the upper.

The *external surface* of the membrana tympani is free, and is directed downwards and outwards; the *internal surface* is turned upwards and inwards, and adheres very firmly to the handle of the bone of the ear, called the malleus, by which it is drawn inwards, so that its centre presents a funnel-shaped depression, which is concave externally and convex within. The circumference of the membrane is fitted, like a watch-glass, into a circular furrow formed at the inner end of the external meatus in the adult, and into the tympanic ring in the fœtus. Above and behind, near its insertion into its bony frame, the membrana tympani is elevated by a small process (the short process) of the malleus.

Immediately on the inner side of the insertion of the membrana tympani, opposite the posterior extremity of a line drawn across its middle, is situated a small foramen, the orifice of a canal which transmits the *chorda tympani nerve.*

Is the membrana tympani perforated? Some anatomists have asserted that there is an aperture between the membrane and the bone, at one point of its circumference; and others have believed that an oblique slit traverses the membrane. But these perforations do not exist in the natural state; so that the membrana tympani forms a complete septum between the tympanum and the external auditory meatus.

Notwithstanding its tenuity and transparency, the membrana tympani consists of three very distinct layers. The *external* or *epidermic layer* is a prolongation of the epidermic portion only of the skin which lines the external meatus.

The *internal* or *mucous layer* is a prolongation of the extremely thin mucous membrane which lines the tympanum. The handle of the malleus is situated between this and the middle layer.

The *middle* or *proper layer*, on which the strength of the membrane depends, appears to be of a fibrous nature. According to Sir Everard Home, it is muscular; he states that he distinctly saw muscular fibres radiating from the centre to the circumference, first in the elephant, and afterwards in the ox, and in the human subject. *

By fine injections some very delicate vessels are demonstrated in the membrane. The network represented by Soemmerring, who only injected the arteries, is not nearly so dense as that which may be displayed by filling the veins. If a blue injection be thrown into the jugular vein of the fœtus, the whole membrane will become of that colour, and will present an exceedingly fine vascular network under a lens. In a new-born infant, which had died with inflammation of the tympanum, the membrane was found quite red. The blood-vessels appear to be situated entirely in the internal layer; they run from the circumference towards the centre of the membrane; and this arrangement has probably led to the supposition of the existence of radiated muscular fibres.

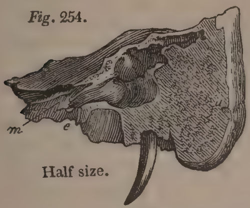
The *use* of the membrana tympani is to transmit the sonorous vibrations, received through the external auditory meatus to the air contained within the tympanum, and to the ossicula of the ear. Its obliquity, besides increasing the dimensions of this vibratile membrane, has certainly some use in the reflection of sonorous vibrations. As it adheres to one of the chains of small bones

* Philosophical Transactions, p. 23. 1823. To his paper are annexed three plates representing the membrana tympani in the elephant, the ox, and man.

of the ear, it is influenced by their movements; and in this way it may be either stretched or relaxed.

The internal wall of the tympanum. The *internal wall* of the tympanum (*figs.* 254, 255.), which is perfectly exposed when that cavity is opened from its external wall, presents a great number of objects for our consideration. At its upper part is situated the *fenestra ovalis* (*f*, *fig.* 254.), the long diameter of which is directed transversely, but rather obliquely downwards and forwards; the upper border of this fenestra (*f*, *fig.* 258.) is semi-elliptical, whilst the lower border is straight, or rather it projects somewhat into the opening. The fenestra ovalis, called also the *vestibular orifice of the tympanum*, would establish a free communication between the tympanum and the vestibule if it were not closed by the base of the stapes (3, *fig.* 255.; *n*, *fig.* 257.), which is accurately fitted to it.

Fig. 254.



Half size.

Natural size.
(Section of the tympanum.)

The fenestra ovalis is placed at the bottom of a depression, which is named the fossette of the fenestra, and the depth of which depends upon the degree of projection of the aqueduct of Fallopius, which bounds it in front, by that of the promontory, which is below, and by an osseous tongue which passes up to the pyramid, behind.

Below the fenestra ovalis is the *promontory* (*r*, *figs.* 254, 255.), an eminence which corresponds to the first turn of the cochlea, and has three grooves upon its surface, that diverge above, and converge below, where they terminate in a common canal, which opens upon the lower surface of the petrous portion of the temporal bone, between the carotid canal and the groove for the internal jugular vein. This canal (canalis tympanicus, *Arnold*), may be called the *canal of Jacobson*, because it contains Jacobson's nerve, a branch given off from the glosso-pharyngeal, which establishes a very remarkable anastomosis between the glosso-pharyngeal and the nervi molles derived from the vidian and great sympathetic nerves.* The furrows upon the promontory are intended to lodge this anastomosis. They are often formed into complete canals.

Behind the fenestra ovalis, and opposite its transverse diameter, is a small projection of variable size, called the *pyramid* (*t*, *figs.* 254, 255.). There is an opening upon it which is distinctly visible to the naked eye, and makes the pyramid appear tubular. From this opening em rges a small cord (*o*, *fig.* 255.), the nature of which is not known, but which is called the *stapedius muscle.* A bristle passed into this opening enters the *canal of the pyramid*, which canal is generally described as ending in a cul-de-sac, but this is not the case. M. Huguier, prosector of the Faculty, has clearly demonstrated, in a series of preparations, that the canal of the pyramid is a long passage, which passes backwards and downwards below the aqueduct of Fallopius, becomes vertical like the aqueduct, is separated from it only by a thin lamina of bone, communicates with it by a small opening, and at length abandons it below, to open upon the inferior surface of the petrous bone, on the inner side of the stylo-mastoid foramen, at a variable distance from it. Sometimes this canal bifurcates below; so that two bristles introduced into the small openings near the stylo-mastoid foramen will both enter the canal of the pyramid. A small, very short, and horizontal passage, which terminates in the diploe of the temporal bone, may be regarded as a diverticulum of this canal.

* This can be clearly seen in some preparations in the museum of the Faculty at Paris.

I have already stated that a fibrous-looking cord, named the stapedius muscle, emerges from the canal of the pyramid. It is not yet known what structures are transmitted through the divisions of this canal.

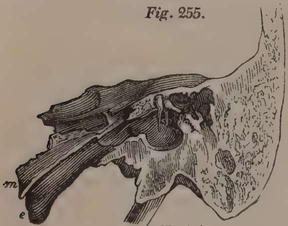
Below the fenestra ovalis, and behind the promontory, is situated the *fenestra rotunda* (*s*, *figs*. 254, 255.); it is placed at the bottom of a funnel-shaped depression, which was well described by M. Ribes as the *fossa of the fenestra rotunda*, at the bottom of which is found a partly membranous and partly osseous lamina, which is the commencement of the spiral septum of the cochlea. In a dry bone, which has been previously macerated, the membranous part being destroyed, the fossa of the fenestra rotunda communicates with the vestibule. Below this compound lamina, *i. e.* at the lower part of the fossa just described, is found the fenestra rotunda (*s*, *fig*. 257.) properly so called, which leads into the tympanic scala of the cochlea (*l*); whence the term *cochlear orifice of the tympanum* is applied to the fenestra rotunda, in contradistinction to the term *vestibular orifice*, which is given to the fenestra ovalis.

The fenestra rotunda is closed, in the fresh state, by a membrane called the *secondary membrana tympani*, which is said to be composed of three layers—a middle layer, an external or tympanic, and an internal or cochlear layer. The two last-named are mucous membranes.*

Under the pyramid, and behind the fenestra rotunda, is seen a deep fossa, *the sub-pyramidal fossa* (*v*, *fig*. 254.), remarkable for its constancy, and pierced by several foramina at the bottom.

Upon the internal wall of the tympanum, in front of the fenestra ovalis, somewhat above the transverse diameter of that opening, and under the prominence of the aqueduct of Fallopius, is the internal *orifice* (*n*, *figs*. 254, 255.) *of the canal* (*m*) *for the internal muscle of the malleus*, or tensor tympani muscle. This orifice is wide and cup-shaped, and is supported by a hollow eminence (*x*, *fig*. 254.), which is itself sustained by several ridges; so that there is the greatest analogy between it and the hollow projection constituting the pyramid. Both of them transmit a tendon. One is situated in front, and the other behind the fenestra ovalis. M. Huguier, who has paid much attention to this subject, has shown that the *cochleariform process of anatomists* (*n*, *fig*. 255.) is nothing more than the remnant of the hollow projection (*x*, *fig*. 254.) just described, one half of which is very thin and fragile, and is sometimes destroyed by long-continued maceration. The so-called cochleariform process therefore is merely the reflected canal for the internal muscle of the malleus.

Fig. 255.



Half size.

Natural size.
(Section of the tympanum.)

The circumference of the tympanum. We shall examine this circumference above, below, in front, and behind.

Above, the tympanum corresponds to the projection formed on the anterior part of the base of the petrous portion of the temporal bone. In it there is formed a recess, which may be named the *recess of the tympanum*, and which is intended for the reception of the head of the malleus (1, *fig*. 255.), and the body and posterior ramus of the incus (2). It is thin and spongy, and is separated from the squamous portion of the temporal bone by a suture, which

* [The internal or cochlear layer is merely a part of the common lining membrane of the labyrinth, and is most probably a *fibro-serous* membrane, see p. 907.]

persists even to the most advanced age. This suture is traversed by a great number of canals, through which communicating vessels pass from those of the dura mater to those of the tympanum.

Below, the tympanum is very narrow, and has the form of a trench, in which there is nothing particular to notice. The wall of the tympanum is here formed by the osseous lamina of the external meatus.

At the *upper* and *back* part of the circumference of the tympanum is situated a large opening which leads into the *mastoid cells* (*c c*, *figs.* 254, 255.).

These cells are extremely numerous, and of very unequal size; they occupy the whole of the mastoid portion, and the adjacent parts of the petrous portion of the temporal bone, and are prolonged even above the external meatus. We may therefore regard the mastoid portion of the temporal bone as an appendage to the tympanum. The mastoid cells have a very regular arrangement in the ox and horse, in which animals they are disposed in a series radiating from the surface of the mastoid process towards the tympanum; their arrangement is much more irregular in the human subject. Two large cells are almost always found, one near the apex, and the other at the posterior border of the mastoid process. In one case I found the whole mastoid process forming a single large cell, having extremely thin parietes.

The mastoid cells are lined with a very delicate fibro-mucous membrane, which is continuous with the mucous membrane of the tympanum. They contain air, and it is only in some cases of disease that any quantity of mucus is found in them.

The mastoid cells represent, in the auditory apparatus, the cells and sinuses which are connected with the organ of smell. It may be easily conceived that the intensity of sounds may be increased by being reverberated from so considerable a surface.

In the fœtus there are no mastoid cells; but there exists instead, in the base of the petrous portion of the temporal bone, a cavity prolonged from the recess already described in the upper wall of the tympanum, for the ossicula of the ear.

In front, the tympanum is contracted like a funnel, to become continuous with the *Eustachian tube* (*e*, *fig.* 255.); it might even be said, that the tympanum and the Eustachian tube form together a single funnel-shaped cavity, the expanded portion of which is constituted by the tympanum, and the contracted portion by the tube of Eustachius.

The canal for the internal muscle of the malleus is formed in the upper wall of the Eustachian tube: it is a narrow tubular canal (*m*), which having reached the anterior part of the tympanum, becomes applied to the internal wall of that cavity; it passes horizontally backwards, forming a projection upon this wall, and is then reflected outwards, at a right angle, to form the hollow eminence already described. This canal is separated only by a very thin osseous lamina from the Eustachian tube; so that the two passages, placed one above the other, have some resemblance to a double-barrelled gun.

The Eustachian Tube.

The *Eustachian tube* (more correctly called the Eustachian *trumpet*, from *tuba*, a trumpet; *e*, *fig.* 255.), or the guttural meatus of the ear, is a straight funnel-shaped canal, flattened upon its outer side, and about two inches in length; it extends from the tympanum to the upper and lateral part of the pharynx, where it terminates by a free, expanded extremity (*m*, *fig.* 234.), directed inwards and downwards, named the *guttural orifice*, or the mouth of the Eustachian tube. This orifice is wide and dilatable, of an oval shape, the larger end of the ovoid being turned upwards, and being exceedingly dilatable; but beyond its mouth the tube almost immediately contracts, and will scarcely admit an ordinary probe. It continues narrow as far as its tympanic orifice, where it again becomes sensibly dilated. It is directed obliquely inwards, forwards, and down-

wards; hence the facility with which the mucus of the tympanum flows into the back of the throat.

The Eustachian tube consists of an osseous portion and of a cartilaginous and fibrous portion.

The *osseous portion*, which is about seven or eight lines in length, is situated at the retreating angle formed between the squamous and petrous portions of the temporal bone.

A triangular *cartilaginous* plate, formed into a groove, constitutes the inner half of the tube: a *fibrous* layer, which is at first applied against the *circumflexus palati* muscle, and is then lodged in the groove between the petrous portion of the temporal bone and the posterior border of the sphenoid, forms the external wall of the canal, which is habitually collapsed. The base of the triangular cartilage, which forms the guttural orifice of the tube, is notched in the middle, and terminates in two thickened elongated angles; of these the posterior one, which is more distinct, is moveable, and may be pushed upwards and backwards. The anterior angle is firmly fixed to the posterior margin of the pterygoid process. As catheterism and injection of the Eustachian tube have become common operations in treating diseases of the ear, it is of importance to define the exact position of its guttural orifice; it is situated (*m*, *fig.* 234.) upon the side of the pharynx, immediately behind, and a little above the inferior turbinated bone.

The *mucous membrane* which lines the Eustachian tube is thin, but at the mouth of the tube it assumes the characters of the mucous membrane of the pharynx and of the pituitary membrane, with both of which it is continuous; it is also continuous with the mucous membrane of the tympanum: hence the close sympathy which exists between the lining membrane of these several parts.*

The use of the Eustachian tube is to renew the air contained within the tympanum; but it also gives exit to the mucous secretion of that cavity.†

Besides the orifice of the Eustachian tube, and that of the canal for the internal muscle of the malleus, the anterior funnel-shaped part of the circumference of the tympanum presents two orifices placed one above the other: the uppermost of these is the internal orifice of the canal for the chorda tympani nerve; the lower one is an oblique fissure, which transmits a fibrous cord called the *anterior muscle of the malleus.* M. Huguier has shown me a number of preparations in which the chorda tympani nerve does not escape through the fissure of Glasserius, but runs in a very narrow special canal, about five or six lines in length, which is situated on the inner side of the Glasserian fissure, and opens at the base of the skull in the retreating angle formed between the squamous and petrous portions of the temporal bone, upon the outer side of the Eustachian tube, behind the spinous process of the sphenoid, and sometimes upon that bone itself.

The fissure of Glasserius, then, merely transmits a fibrous bundle, named the anterior muscle of the malleus, and some small arteries and veins.

We may now describe the course of the chorda tympani nerve.

In its course this nerve passes through *two canals*, entering the tympanum by one, and escaping from it by the other. The canal by which it enters commences at the vertical portion of the aqueduct of Fallopius, in which the facial nerve is situated, passes upwards and forwards, and opens immediately on the inner side of the posterior margin of the membrana tympani, on a level with the horizontal diameter of that membrane, and almost in the groove into which it is inserted. Having entered the tympanum through this canal, the

* [According to Dr. Henlé, the mucous membrane of the Eustachian tube, like that of the upper part of the pharynx, is covered with a columnar ciliated epithelium; but in the tympanum and mastoid cells the epithelium is squamous, and not ciliated.]

† [The Eustachian tube, by establishing a communication between the tympanum and the external air, ensures an equal atmospheric pressure on the two surfaces of the membrana tympani, so that the necessary condition of that membrane, and of the ossicula auditûs, as conductors of vibrations, is not interfered with.]

chorda tympani describes a curve, having its concavity directed downwards, passes between the handle of the malleus and the long ramus of the incus, enters its proper canal upon the inner side of the fissure of Glasserius, and emerges at the point already mentioned.

The Ossicula of the Ear.

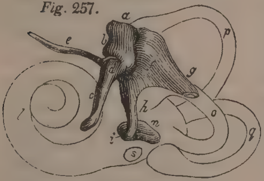
The tympanum is traversed from without inwards by an osseous chain, which describes several angles, and consists of four bones articulated with each other, and extended from the membrana tympani to the fenestra ovalis. These little bones, forming the links of the chain, are named, from their respective shapes, the *malleus*, or hammer (1, *fig.* 256.); the *incus*, or anvil (2); the *os orbiculare*, or round bone (4); and the *stapes*, or stirrup-bone (3): the os orbiculare, however, appears to be merely a tubercle belonging to the incus.

Fig. 256.

The malleus. The malleus (1, *fig.* 256.) is the most anterior of the bones of the ear; it is divided into a *head*, a *neck*, and a *handle*, and it has also two *processes*.

The *head* of the malleus (*a*, *fig.* 257.) is situated in the recess of the tympanum, in front of the incus, and above the membrana tympani. It is ovoid, and smooth, excepting behind and below, where it is concave in order to be articulated with the incus. Sömmerring has figured a small fibrous cord, which he calls the *proper ligament of the malleus*, extending from the head of this bone to the upper part of the recess of the tympanum.

Fig. 257.



Magnified three diameters.

The head is supported by a constricted *neck* (*b*), which is slightly twisted and flattened, and serves also as a support for the two processes.

The *handle* (manubrium, *c*) is directed vertically, and with the head and neck forms a very obtuse angle, which retreats on the inner side; it is in contact with, and adheres firmly to the internal surface of the membrana tympani, opposite the centre of which its rounded extremity is placed; it therefore forms a radius to the circle represented by the membrana tympani. The lower part of the handle of the malleus is distinctly curved, having its concave side turned outwards; this explains the funnel-shaped depression upon the external surface of the centre of the membrana tympani.

The *processes* of the malleus are two in number; the external, or *short* process (*d*), is directed slightly outwards, and rests against the upper part of the margin of the membrana tympani, so as to make it project outwards; the other, or *long* process, is very slender (*processus gracilis of Raw*, *e*), and is shaped like a thorn (*processus spinosus*): it arises from the *anterior* part of the neck, enters the Glasserian fissure, and affords attachment to a muscular or fibrous cord. I have several times found a simple ligamentous cord instead of this process.

The incus. This bone (2, *fig.* 256.) has been well compared to a bicuspid tooth, the body of which would be represented by the *body* of the incus, and the *fangs* by its two *processes*.

The *body* (*f*, *fig.* 257.) is contained in the recess of the tympanum, behind the malleus, with which it is articulated by a very concave surface, directed forwards and somewhat upwards; so that the articulation between the head of the malleus and the body of the incus is effected by mutual reception.

Of its two rami, the *superior*, or *short* one (*g*), is thick, conoid, and directed horizontally backwards: it is situated upon the same plane as the body, and like it is contained in the recess of the tympanum, in which it terminates; its extremity does not appear to me to be free.

The *inferior*, or *long* ramus (*h*), is longer and thinner than the superior one; it passes vertically downwards, parallel to the handle of the malleus, on a plane

internal and somewhat posterior to it. Its lower portion is bent into a hook, the concavity of which is turned inwards; and at its point is formed a sort of *lenticular* and distinctly defined *tubercle* (4, *fig.* 256.; *i*, *fig.* 257.), which has been regarded as a separate bone, and named the *os orbiculare*, or *os lenticulare*; it appears to me to be merely a dependence of the incus, with which I have always found it united, even in the fœtus.

The stapes. The *stapes* (3, *fig.* 256.), which is shaped like a stirrup, extends horizontally from the extremity of the long process of the incus to the *fenestra ovalis* (see *fig.* 257.), and is situated upon a lower plane than the rest of the small bones of the ear. Its *head* presents a small articular cavity, for the reception of the orbicular tubercle of the incus. Its *base* (*n*) is directed inwards, and consists of a thin plate exactly corresponding to the fenestra ovalis, which is rather accurately filled up by it, and to draw it away from which a slight force is necessary, so that it has a greater tendency to fall into the vestibule than into the cavity of the tympanum. The slight obliquity of the long diameter of the fenestra ovalis causes an inclination of the stapes in the same direction. Of its two crura, or *branches* (*fig.* 256.), the anterior is the shorter and straighter. Upon those surfaces of the crura which are turned towards each other there is found a groove, which appears to indicate the existence of a membrane stretched between the crura. I have found the stapes very small, and, as it were, atrophied. In one case, the two crura of the stapes were united together.

Muscles belonging to the Ossicula of the Ear.

Most modern anatomists agree with Soemmerring in admitting four muscles for the ossicula of the ear, viz. three belonging to the malleus, and one to the stapes. The incus has no proper muscle, because it is merely an intermediate bone between the malleus and the stapes. It is certain, however, that only one of these muscles has been actually demonstrated, viz. the *internal muscle of the malleus*; but it is so easy to fall into error when examining such minute objects, that I feel bound to suspend my judgment as to the existence or non-existence of the other muscles.

The *internal muscle of the malleus*, or *tensor membranæ tympani* of Soemmerring (*e*, *fig.* 251.), is an elongated, fusiform muscle, contained within the bony canal formed in the retreating angle of the temporal bone, above the Eustachian tube, with which it exactly corresponds in direction. It *arises* from the cartilaginous portion of the tube, from the adjacent part of the sphenoid bone, behind the spinous foramen, and from the bony canal which forms its sheath. The fleshy fibres converge around a tendon, which appears from among them, before it passes out from the bony canal. This tendon is reflected at a right angle, like the canal in which it is contained, and then passes directly outwards, to be inserted into the anterior and superior part of the handle of the malleus, below the processus gracilis of Raw.

The muscularity of the band or cord named the *anterior muscle* or *ligament of the malleus*, or the great external muscle of Meckel, is doubted by a great number both of present and former anatomists.* I have never seen any thing more than a fibrous cord, which commenced at the tip of the processus gracilis of the malleus, traversed the glenoid fissure, was reinforced by other fibres arising from that fissure, and became continuous with a fibrous layer arising from the spinous process of the sphenoid bone, and generally regarded as the internal lateral ligament of the temporo-maxillary articulation.

The same remarks will also apply to the *small external muscle of the malleus*, or small muscle of the malleus of Casserius. This muscle is figured by

* "Fuêre autem et dudum et nuper clari viri qui de veris hujus musculi fibris carneis dubitarunt, cum multam quidem membranam a periosteo propagatam, sulcum maxillæ repleri viderent, et processui longissimo circumnasci, cæterum in eo carneam naturam non deprehenderent. Neque mea experimenta rem expediunt. Musculum quoties volui, ostendi, num veras fibras viderem, plerumque dubius hæsi." (*Haller*, tom. v. lib. xv. p. 218.)

Soemmerring, who says that he found it exceedingly developed in one subject. All that I have clearly seen is a cylindrical cord, extending from the upper part of the frame of the membrana tympani to the short process of the malleus, or rather below it, according to the observations of Soemmerring (*ad manubrium mallei, infra brevem ejus processum*). This small muscle would relax the membrana tympani; hence it has been named by Soemmerring, the *laxater membranæ tympani.*

The *muscle of the stapes*, or *stapedius* muscle (*o, fig.* 255.), which is the smallest in the body, has, since the time of Varolius, by whom it was discovered, been regarded as a ligament by some anatomists; nevertheless, it is more generally admitted to be muscular than that last described. It arises from some part of the interior of the pyramid, and escaping from that process passes forwards, and terminates at the back of the neck, or constricted part of the head of the stapes, behind its articulation with the incus. Soemmerring has not only represented its fleshy belly and its tendon, but also (see fig. 20. tab. 11.) a filament of the facial nerve terminating in it. It is difficult to conceive that such a serious mistake should have been committed by this great anatomist. I have examined this cord under a lens, and have never been able to discover any muscular fibres in it. We do not conceive how a muscle should exist in so delicate a cord. Supposing, however, that it does exist, it must move the stapes in such a way that the posterior extremity of the base of that bone would be pushed into the fenestra ovalis, whilst the anterior extremity would be carried outwards.

Movements of the ossicula. The chain of small bones in the ear is so arranged, that any movement of one of its extremities is communicated to the entire chain. Their motion is precisely similar to that of a bell-crank. M. Huguier is inclined to believe that the processus gracilis of Raw serves as a fulcrum, around which the malleus performs a rotatory movement, the effects of which are transmitted to the stapes through the incus. The contraction of the internal muscle of the malleus, or tensor membranæ tympani, must draw the handle of the malleus inwards and its head outwards; the incus, from its firm connection with the head of the malleus, follows that bone, and as it swings upon its short horizontal process, its vertical process is carried inwards, and therefore presses the stapes into the fenestra ovalis.

The Lining Membrane of the Tympanum.

The tympanum is lined by a very thin membrane, which not only covers the walls of this cavity, but also forms a very evident investment for the ossicula, and is moreover prolonged into the mastoid cells, lining them throughout, and forming small duplicatures around the vessels by which some of the cells are traversed. This membrane is continuous with the mucous membrane of the Eustachian tube, and therefore indirectly with that of the pharynx.*

It serves at once as an internal lining for the tympanum, and a periosteum for the osseous walls of that cavity, and should therefore be regarded as a fibro-mucous membrane. It secretes a mucus, which in the natural state simply moistens its surface, but in some cases of disease occupies the whole cavity. The catarrhal character of the products of suppuration in the tympanum, the continuity of this lining membrane with the mucous membrane of the pharynx, and its extreme vascularity, leave no doubt of its being a mucous membrane.

* See note, p. 896.

The Internal Ear, or Labyrinth.

The *internal ear*, or *labyrinth* (*f, fig.* 251.), the deep-rooted and essential portion of the organ of hearing, is situated on the inner side of the tympanum, in the substance of the petrous portion of the temporal bone. It consists of the *osseous labyrinth*, which forms a receptacle for the *membranous labyrinth*, which is the immediate seat of the sense of hearing. No part of the body has a more complex and delicate structure. The labyrinth is composed of three very distinct compartments, which have been named the *vestibule*, the *semicircular canals*, and the *cochlea*.

The Osseous Labyrinth.

Preparation. This is justly regarded as one of the most difficult dissections, even when the parts are previously known. The dissection should be made upon temporal bones from subjects of different ages, upon bones that have been macerated, upon others that have been dried without maceration, and also upon bones in the fresh state. Commence with a fœtal temporal bone, in which the labyrinth can very easily be isolated, in consequence of its being surrounded only by a spongy texture, readily yielding to the knife. In the adult, the labyrinth is, in proportion, much less developed than in the fœtus, and is surrounded with so compact a tissue, that, in order to cut it, it is necessary to use a chisel, a file, or a very strong scalpel. It is important to have a great number of temporal bones, so as to be able to make several different sections.

Preparation of the vestibule. Open the vestibule through its upper wall, which corresponds to the upper surface of the petrous portion of the temporal bone, opposite the fenestra ovalis, between the superior vertical semicircular canal and the internal auditory meatus.

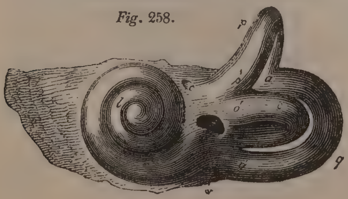
Preparation of the semicircular canals. In the fœtus, one of the semicircular canals projects upon the base of the petrous portion of the temporal bone; it is easy to isolate it, as well as the other canals, by removing, with a strong scalpel, the spongy tissue in which they are imbedded. It is useful to have two preparations of the semicircular canals; one in which the canals remain entire, and another in which they have been opened.

Preparation of the cochlea. Remove layer by layer that part of the petrous portion of the temporal bone which corresponds to the bottom of the internal auditory meatus. A layer of very thin spongy tissue shows, in the fœtus, that we have arrived at the cochlea; remove this spongy tissue with care, and expose the cochlea, both on its upper and lower surfaces. In one preparation, the cochlea should be merely isolated; in another, it should be carefully opened, and for this purpose it is sufficient to make a simple cut into each of its turns: it is of importance not to remove the summit of the cochlea.

The Vestibule.

If a probe be passed from the tympanum through the fenestra ovalis (*f, fig.* 258.), it enters an ovoid cavity (*a b t, fig.* 259.) called the *vestibule*.

Fig. 258.

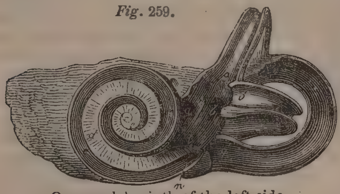


The vestibule is the centre of the internal ear, and forms an intermediate cavity or passage (forum fodinæ metallicæ, *Vesalius*) between the semicircular canals (*o p q, fig.* 258.), which are on its outer side, and the cochlea (*l*), which is to its inner side. It is situated in a line with the axis

of the internal auditory meatus. It is remarkable for having a great number of both large and small openings into it.

The *large openings* are seven in number: the first is the *fenestra ovalis* (*f*, *figs.* 258. 261.), which would establish a free communication between the vestibule of the tympanum if it were not for the base of the stapes, which closes it hermetically, as we may be convinced by examining it from the vestibule, when the stapes remains in its place.* There are *five* openings (*o' p' q'*, *fig.* 259.; *o' a'*, *fig.* 261.) for the three semicircular canals; and the seventh is the orifice (*t*) of the vestibular scala of the cochlea. In macerated bones we find, besides, an eighth opening, situated below the fenestra ovalis, having an oblong shape, and leading into the highest part of the fenestra rotunda.

Fig. 259.



Osseous labyrinth of the left side. Magnified two diameters.

Of the *small openings*, the first is the *orifice* (*r*, *fig.* 259.) *of the aqueduct of the vestibule*, which opens upon the posterior wall of this cavity to the inner side of the common opening for the two vertical semicircular canals (*i. e.* in the recessus sulciformis). The aqueduct of the vestibule turns a short distance around that common opening, and then bending at a right angle, terminates upon the posterior surface of the petrous portion of the temporal bone by an orifice already described (see OSTEOLOGY). The other small openings in the vestibule are foramina for the passage of vessels and nerves; they form the *macula cribrosa*, which corresponds with the bottom of the internal auditory meatus.

The character of the vestibule is irregularly ovoid, and is divided by a *crista* into two fossæ; one inferior and hemispherical, named the *fovea hemispherica* (*a*, *fig.* 259.), the other, superior and semi-elliptical, called the *fovea semi-elliptica* (*b*). Morgagni has described a third groove-like fossa (*recessus sulciformis*), situated at the mouth of the common orifice of the two superior semicircular canals.

The Semicircular Canals.

The *semicircular canals*, three in number, represent three cylinders or tubes (tubæformes canales, *Soemmerring*), of equal diameters, and curved very regularly, so as to describe portions of circles; they are situated within the substance of the base of the petrous portion of the temporal bone, behind the vestibule, into which they open by the five orifices already described.

They have been named the *great*, the *middle*, and the *small* semicircular canals; terms which have caused much confusion, because the differences between them, in regard to length, are not alone sufficient to distinguish them from each other.

Their *direction* forms a much better ground of distinction between them. Two are *vertical*, and one is *horizontal*: there is an *anterior* and *superior* vertical, and a *posterior* and *inferior* vertical canal; the horizontal canal is *external*, and is situated between the two others.

The *superior vertical canal* (*p*, *figs.* 258. 260.), which describes two thirds of a circle, is placed at the highest part of the labyrinth, immediately to the outer side of the vestibule. A plane passing through the two branches of this canal would cut the base of the petrous portion almost at a right angle.

The convexity of this canal is turned upwards, and its concavity downwards. In the fœtus, its concavity is free, so that it can be seen without any dissection; but in the adult it is filled up with osseous tissue.

* [The base of the stapes is retained in its situation, and the complete closure of the fenestra ovalis is effected, by the reflection of the lining membrane of the tympanum on the one hand, and by that of the lining membrane of the labyrinth on the other.]

The anterior and outer extremity (*p′*, *figs.* 258, 259.) of this canal is dilated into an *ampulla*, and opens separately at the upper and outer part of the vestibule. The posterior and inner extremity unites with the corresponding extremity of the inferior vertical canal to form a common canal (*a*, *fig.* 260.), which opens without any dilatation into the upper and inner part of the vestibule (*a′*, *fig.* 261.).

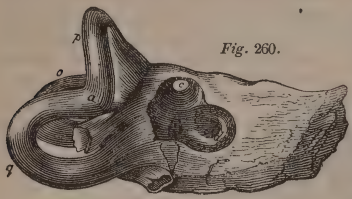


Fig. 260.

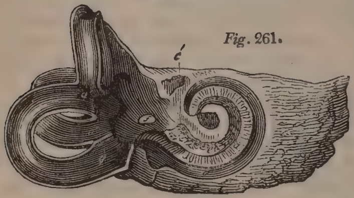


Fig. 261.

The *inferior vertical canal* (*q*, *figs.* 258, 260.) is placed at right angles to the preceding, and parallel with the posterior surface of the petrous portion. It commences at the inner and upper part of the vestibule, by the common canal (*a*, *fig.* 260.) already described, passes almost directly outwards, curves at first downwards, and then forwards, and becomes dilated into an *ampulla* (*q′*, *fig.* 258.) near the vestibule, into which cavity it opens (*q′*, *fig.* 259.), about the distance of a line from the point at which it commences. This canal, therefore, describes nearly a complete circle; and hence the term *canalis major et longior*, still given to it by Soemmerring, in contradistinction to the superior vertical semicircular canal, which he calls *minor et brevior.*

The *horizontal canal* (*o*, *figs.* 258. 260.), *canalis minimus, brevissimus, sive exterior* of Soemmerring, commences in the vestibule (*o′*, *figs.* 258, 259.) between the fenestra ovalis, which is below, and the ampullar opening of the superior vertical canal, which is above; it becomes dilated into an *ampulla*, describes a horizontal curve having its convexity turned outwards, and opens (*o′*, *fig.* 261.) upon the inner wall of the vestibule, between the common opening (*a′*) of the two vertical canals and the proper opening (*q′*) of the inferior vertical canal.

It appears, then, that each of the three semicircular canals has one of its extremities dilated into an ampulla, and the other not dilated; that the two vertical canals unite by their non-dilated extremities; that of the five openings belonging to the semicircular canals, two occupy the outer, and three the inner wall of the vestibule, and that the three last consist of the common canal formed by the two vertical canals, by the ampullar extremity of the posterior vertical canal and by the non-ampullar extremity of the horizontal canal.

The Cochlea.

The *cochlea* (*l*, *fig.* 258.), or *snail*, so called from its resemblance to the shell of that molluscous animal, may be said to consist of a conoid tube, which is subdivided into two cavities, called *scalæ*, by a septum extending from its base to its apex, and is coiled upon itself into a spiral containing two turns and a half.

The cochlea is the most anterior part of the internal ear; it is situated on the inner side, and in front of the tympanum; its base (*d*, *fig.* 260.) rests upon the bottom of the internal auditory meatus.*

Its external surface is blended, in the adult, with the substance of the petrous portion of the temporal bone, so that it requires much skill to carve it out without breaking into its cavity: in the fœtus, on the contrary, such a dissection is extremely easy, on account of the thin layer of spongy osseous tissue by which it is separated from the rest of the bone.

* [The summit of the cochlea is directed forwards, downwards, and outwards. The gyri of the cochlea are coiled in a direction from below upwards, and from without inwards.]

The following parts of the cochlea are separately described — the *tube of the cochlea* or *lamina gyrorum*, the *lamina spiralis*, the *axis* or *columella*, the two *scalæ*, and the *aqueduct*.

The tube of the cochlea. The tube of the cochlea (*canalis spiralis cochleæ*, or *lamina gyrorum*) is the compact lamina (*l*, *figs.* 258. 262.) which forms the external walls of the cochlea. If we imagine a hollow osseous cone, coiled spirally, *sicut circa fulcrum convolvulus* (*Haller*), or like a winding staircase; and further, that the lowest turn of the spire embraces the turn above it, and that the walls of the different turns are blended with each other, we shall have a correct idea of the tube of the cochlea: as before stated, the spire thus formed describes two turns and a half.

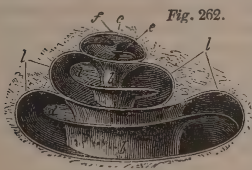
The spiral lamina of the cochlea. The spiral canal, or tube of the cochlea, is subdivided lengthwise into two secondary cavities (*c e*, *c e*, *figs.* 263, 264.) called *scalæ* (*scala*, a staircase) by a septum (*a*), which is named the spiral lamina of the cochlea (*lamina spiralis cochleæ*).

Commencing at the base of the cochlea (*t*, *fig.* 259.; also *fig.* 263.), and at the fenestra rotunda, where it can be very easily seen, the spiral lamina winds edgewise, around the axis or columella (*b b*, *fig.* 262.), and is continued without any interruption to the summit or cupola (*f*) of the cochlea, the several turns of which it exactly follows. Its *internal border* is applied against the axis of the cochlea, and adheres intimately to it, excepting above, where it is free for a short distance, and leaves a communication (*n*, *fig.* 263.) between the two scalæ. *Margo liber laminæ spiralis quo fit ut utriusque scalæ sit communicatio* (*Soemmerring*). Its *external border* adheres to the inner surface of the lamina gyrorum, or tube of the cochlea. In consequence of the conical form of this tube, the lamina spiralis would, if unrolled, represent an isosceles triangle, the base of which had corresponded to the fenestra rotunda, and the apex to the summit of the cochlea.

The *spiral lamina* consists of two portions — an internal *osseous* and an external *membranous portion.**

The osseous portion (*lamina spiralis ossea*; *d*, *figs.* 259. 261, 262. 264.) predominates in the first turn, diminishes gradually in the second, and ceases at the commencement of the third, where it terminates in a kind of *hook* or *beak* (*hamulus vel rostrum*; *e*, *fig.* 262.). This bony portion is thick, and consists of two lamellæ, between which are found a great number of very delicate canals, through which the nerves of the cochlea pass. These two lamellæ form two distinct furrows upon the columella.

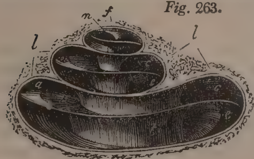
Fig. 262.



Cochlea (dry).
Magnified four diameters.

The membranous portion (*lamina spiralis membranacea*; *a a*, *figs.* 263 to 265.), completes the septum, forming its outer part. It is narrow in the first turn of the cochlea, becomes broader in the second, and constitutes the entire septum in the third.

Fig. 263.



Cochlea (recent).

The bony and membranous portions of the spiral lamina, therefore, represent two isosceles triangles, so arranged that the base of the one corresponds to the apex of the other, and *vice versâ*.

Moreover, as Comparetti remarks, three zones can be distinguished in the membranous portion of the spiral lamina, the consistence of which diminishes progressively from the margin of the osseous lamina towards the internal surface of the tube of the cochlea.

* [In the dried cochlea (*fig.* 262.) the two scalæ communicate along their whole course.]

The axis or columella of the cochlea. From the bottom, or rather from the posterior part (*d, fig.* 260.) of the bottom of the internal auditory meatus, arises a bony process, which is directed almost horizontally outwards; it occupies the centre or axis of the cochlea, and around it both the tube and spiral lamina describe their several turns. This bony process is called the *axis of the cochlea, columella, modiolus,* or *nucleus* (*b, figs.* 262. 264.). It extends from the base to the summit of the cochlea, but undergoes certain changes during its course. Opposite the first turn it is extremely thick, but becomes much thinner in the first half of the second turn. In the second half of the second turn, and in the last half turn, it is replaced by a cup-shaped lamella, called the *infundibulum* (scyphus, *Vieussens; c, fig.* 262.), the expanded portion of which is turned towards the cupola (*f*) of the cochlea. The modiolus or axis of the cochlea, then, has three perfectly distinct parts.

The *base* of the modiolus, which is seen at the bottom of the auditory meatus, is marked by a very distinct spiral tract (*d, fig.* 260.), perforated with foramina, through which the filaments of the auditory nerve are transmitted. It is the *tractus spiralis foraminulentus* of Cotugno.

The *apex* of the modiolus when examined in a cochlea which has been opened from the under surface of the petrous portion of the temporal bone, presents a decidedly infundibuliform figure. But in a cochlea which has been opened from its upper surface (*fig.* 264.), on the contrary, it has the appearance of a very slender stalk, continuous with the rest of the modiolus, and proceeding directly to the cupola of the cochlea. This twofold structure depends upon the fact, that the terminal lamella of the modiolus forms only half a funnel, which half is turned towards the lower half of the cochlea. This *terminal lamella of the modiolus*, which has been very well described by Huguier, is of a triangular form, extends through half a turn of a spiral, and adheres to the inner surface of the tube of the cochlea by its external convex border. Its internal border or margin is straight and free, and is the only part of this lamella which is seen when the cochlea is opened from above, whilst its convex border and its surfaces are distinctly seen when the cochlea is opened from below. The hamulus (*e, fig.* 262.) of the osseous portion of the lamina spiralis terminates opposite the middle of this free border or margin.

The surface of the modiolus is marked like a screw by two furrows corresponding to the two lamellæ of the osseous part of the spiral lamina; this surface is pierced with foramina for the branches of the auditory nerve.

If the modiolus be divided longitudinally (*fig.* 264.), it will be seen that its centre is traversed by a number of canals, for the passage of the branches of the auditory nerve. These canals open by the foramina on its surface. In the centre of the half funnel formed by the terminal lamella of the modiolus is an opening, through which the terminal filament of the cochlear branch of the auditory nerve passes out; it is the orifice of the *tubulus centralis modioli*.

Fig. 264.

Cochlea magnified.

The scalæ of the cochlea. The spiral lamina (*d d, fig.* 264.) divides the cavity of the tube of the cochlea into two secondary cavities (*c e, c e*), called the *scalæ* of the cochlea. They are distinguished as the *external, superior,* or *vestibular scala* (scala vestibuli; *c c, figs.* 263, 264.), and the *internal, inferior,* or *tympanic scala* (scala tympani; *e e*). The first (*c c, fig.* 265.) communicates directly with the vestibule (between *t* and *s*); the second, which commences at the fenestra rotunda (*s, fig.* 258.), would communicate with the tympanum if that fenestra were not closed by a membrane; hence the term *scala clausa*. The tympanic scala is decidedly larger than the vestibular. The *section* of either of the scalæ, at right angles to its axis, is semicircular.

The two scalæ communicate near the summit of the cochlea (at *n, figs.* 263.

265.). Both the situation and nature of this communication can be easily ascertained, and have been well described by Soemmerring, and more recently by MM. Breschet and Huguier.

The lamina spiralis, which, we have seen, adheres closely to the modiolus, continues to wind spirally around the half-funnel-shaped termination of the modiolus, but when it arrives opposite the concavity of this half funnel, it ceases to be attached to that concavity, its internal border becomes free, and is then continued on to the inner surface of the summit of the cochlea. It follows therefore that the free concave border of the lamina spiralis is opposite to the concavity of the infundibulum ; and hence there is an interruption in the septum, in the form of a *circular opening*, the *canalis scalarum communis* of Cassebohm, the *helicotrema* of Breschet (*n, figs.* 263. 265.), which establishes a communication between the two scalæ : moreover, this opening is not situated precisely at the summit of the scalæ, but a little below that point; nor is the opening of communication (between *t* and *s*, *fig.* 265.) between the vestibular scala and the vestibule situated at the lowest part of that scala.

The aqueduct of the cochlea. The *aqueduct of the cochlea* opens at one end (*n, fig.* 259.) into the tympanic scala of the cochlea near the fenestra rotunda, and at the other, by an expanded extremity, upon the lower border of the petrous portion of the temporal bone near the jugular fossa. It does not appear to have any such use as was attributed to it by Cotugno. Like the aqueduct of the vestibule, it is merely a canal for a vessel, and as such was denominated by Wildberg, *canalis venosus cochleæ.* The liquor Cotunnii could not pass through this canal, for it is closed by the dura mater. Ilg has taken a very ingenious view of the structure of the modiolus and cochlea. According to that author, the modiolus is not an osseous centre independent of the lamina gyrorum, but rather the internal wall of the spiral tube of the cochlea, which in describing its first turn intercepts a considerable cylindrical space of about two lines and a half in diameter, and then a smaller but still cylindrical space, of about half a line in diameter, in its second turn ; whilst in the third turn there is no space, and therefore the axis or modiolus is wanting, but it is replaced by the internal wall of the spiral tube of the cochlea itself. The terminal lamella of the modiolus would therefore be formed by the internal wall of the spiral tube.

This view is supported by the structure of the bottom of the internal auditory meatus, on which is found a turn and a half of a spiral groove, precisely corresponding to the spire of the cochlea, and by sections of the cochlea made after Soemmerring's plan from the apex to the base. (*Vide* figs. 11, 12, 13, 14, 15. of Soemmerring's fourth plate.)

The Membranous Labyrinth.

The *membranous labyrinth*, discovered by Comparetti and Scarpa, has been correctly described and figured by Soemmerring. M. Breschet has recently enriched our knowledge of this intricate anatomical subject, with many most interesting facts. (*Etudes anatomiques et physiologiques sur l'organe de l'ouie et sur l'audition dans l'homme et les animaux vertebres*, 1833.)

It is useless to attempt the examination of the membranous labyrinth in the human subject without some previous preparation. If the labyrinth be opened, it is found to contain a fluid ; the eye can detect nothing else. By previously macerating it in diluted nitric acid, the twofold advantage is gained of softening the bones, so that they can be cut with a scalpel, and of hardening and rendering opaque the nervous tissues. Before studying the membranous labyrinth in the human subject, it should first be examined in the large cartilaginous fishes, such as the ray and the turbot, in which it is most highly developed. It is then seen that the semicircular canals and the vestibule contain, besides a fluid, certain *semi-transparent membranous tubes* and *sacs*, the aspect of which closely resembles that of the retina.

The membranous labyrinth (*fig.* 265.) is not so extensive as the osseous labyrinth: thus, it does not enter the cochlea, and its diameter is much less than that of the bony labyrinth. It scarcely occupies one half the cavity of the latter.

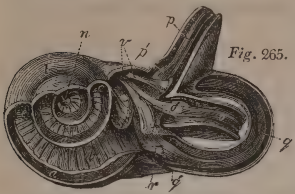


Fig. 265.

Membranous labyrinth (left side).

The space between the bony and membranous labyrinths is filled with a limpid fluid, named after Cotugno, the *liquor Cotunnii*, although it had been noticed by several anatomists before that author. (*De aquæ ductibus auris humanæ internæ.* Cotugno, 1760.) It is the *perilymph* of M. Breschet. There is no air in the labyrinth; and it is somewhat singular that so accurate an anatomist as M. Ribes should have recently defended a contrary opinion, although it has been repeatedly refuted.

The membranous labyrinth is itself filled with a fluid, which was correctly described by Scarpa, and which might be named the *fluid of Scarpa*. M. de Blainville has compared it to the vitreous humour of the eye, and has named it *la vitrine auditive*: it is the *endo-lymph* of M. Breschet.

The membranous labyrinth consists of membranous semicircular canals, and of a vestibular portion.

The Membranous Semicircular Canals.

The *membranous semicircular canals* (*o p q*, *fig.* 265.) were regarded as nervous cords by Scarpa, who first described them; they have precisely the same form as the osseous semicircular canals, although they do not completely fill them. Soemmerring improperly calls them *tubuli membrano-cartilaginosi.* Each membranous canal, like the corresponding osseous one, has its *ampulla*, or *ovoid* vesicle (*o' p' q'*).

The two vertical membranous canals unite at one end into a common canal, and therefore the three membranous semicircular canals, like their osseous investments, open into the membranous vestibule by five distinct orifices.

The *membranous vestibule* consists of two very distinct parts, the *common sinus* and the *saccule.*

The sinus communis vestibuli, or *vestibular utricle* (*u*)*, as was first shown by Scarpa, forms the confluence of the membranous semicircular canals which open into it by five orifices. The utricle is situated in the fovea semi-elliptica of the vestibule, and floats as it were in the liquid of Cotugno; it is distended by the liquid of Scarpa, so as to resemble an oblong bulla. The liquid of Cotugno separates it from the base of the stapes, as Scarpa very well pointed out.

The *sacculus vestibuli*, or vestibular saccule (sacculus proprius sphæricus, *Soemmerring*; *s*) is much smaller than the utricle. Its connexions with the utricle have been compared by Fischer to those of the crystalline lens with the vitreous body: it occupies the fovea hemispherica of the vestibule, and is therefore situated below the utricle. According to Soemmerring it does not adhere to the utricle; that author has even represented a small space between these two parts.† According to others there is a communication between them, and the saccule is merely a supplementary cavity to the utricle. I have not yet been able to satisfy myself concerning this point.

The membranous labyrinth, then, is quite distinct from the membrane

* *Alveus utriculosus* of Scarpa, *utriculus communis* of Soemmerring, *sinus médian* of M. Breschet.

† Sacculus teres cum utriculo communi nullibi cohæret, et ubi cultri apice aperitur, sphæricam formam retinet. (Explanation of fig. 2. pl. 3.) According to M. Breschet, the sacculus and utriculus adhere intimately, and he is inclined to believe that their cavities even communicate, but from the extreme delicacy of these structures, he has been unable to confirm this supposition.

which lines the labyrinthic cavities. This periosteal membrane, which analogy would lead us to regard as a fibro-serous membrane, is the only membrane which is prolonged into the cochlea. We might, however, regard that portion of the lamina spiralis, which is next to the inner surface of the lamina gyrorum, as a portion of the membranous labyrinth.

The calcareous matter of the vestibule. The examination of the ear of fishes, which has proved of such assistance in investigating the structure of the human membranous labyrinth, has also led to the inquiry, whether there existed any thing in the human ear analogous to the solid calcareous concretions found in the labyrinth of the ear of fishes. From the researches of M. Breschet it appears, that the labyrinthic stones, or *otolithes*, of fishes are represented in all the mammalia, and consequently in man, by a cretaceous powder, which he has named *otoconia* (*οὖς*, *ὠτὸς*, the ear, and *κόνις*, dust); and that this powder exists both in the utricle and the sacccule, collected together into two white shining masses, which were seen and described by both Comparetti and Scarpa, but were mistaken by them for the dried acoustic nerve. Does it fulfil the same uses as the otolithes in fishes? or should it be regarded as a rudimentary condition of an important structure in other animals?

The Auditory Nerve and the Vessels of the Ear.

The *auditory nerve*, or special nerve of the organ of hearing, is remarkable for its softness, and hence it has been named the *portio mollis* of the seventh cranial nerve. The auditory nerve arises, at least in part, from the anterior wall of the fourth ventricle; having reached the bottom of the internal auditory meatus, it divides into two branches—an *anterior* and larger, distributed to the cochlea, and a *posterior*, intended for the vestibule and semicircular canals. The anterior or *cochlear branch* (*t*, *fig.* 264.) has a spiral arrangement, like that portion of the bottom of the auditory meatus (*d*, *fig.* 260.) to which it proceeds, and it enters through the foramina in the tractus spiralis of the lamina cribrosa. One set of nervous filaments enters the small canals in the centre of the modiolus (*b*, *fig.* 264.); the others are applied to the surface of the modiolus (*t*, *fig.* 263.); the latter filaments spread out upon the first turn of the lamina spiralis (*t*, *fig.* 265.), radiating in the most regular manner, and having arrived near the outer border of the spiral lamina, they each divide into two or three ramuscules, which anastomose together, so as to form a nervous expansion.* These radiating filaments are more distinct upon the lower than upon the upper surface of the spiral lamina.

Those filaments of the nerve which are not spread out upon the first turn of the lamina spiralis, pass through the foramina in the centre of the modiolus, and spread out upon the second turn in the same manner as those already described. Lastly, the highest filaments emerge from the opening at the apex of the modiolus, and terminate in a similar manner. It follows, therefore, that the nerves of the cochlea successively diminish in length, as the spiral lamina does in width; and thus the radiating nervous filaments resemble the strings of a harp, in becoming successively shorter and shorter. It is probable that this arrangement is not without its influence upon the function of hearing. In a temporal bone softened by the action of nitric acid, the auditory nerve, the modiolus, the spiral lamina, and the periosteal membrane which lines the cochlea, may be dissected with the greatest facility.

The posterior or *vestibular* division of the auditory nerve is subdivided into three branches, the largest of which (*v*, *fig.* 265.) is distributed to the utricle (*u*) and to the ampullæ (*o′ p′*) of the superior vertical and horizontal membranous semicircular canals; the middle-sized branch is distributed to the

* [According to observations made by Treviranus, Gottsche, and others, the filaments of the cochlear nerve in animals do not anastomose, but terminate in isolated extremities, which are in some cases papillary (*Treviranus*), and in others club-shaped (*Gottsche*).]

sacculus (s), and the smallest ends in the ampulla (q') of the inferior vertical membranous semicircular canal.*

Bloodvessels may be traced into the membranous labyrinth; most of them enter by the internal auditory meatus; those which belong to the cochlea pass through the foramina in the modiolus, and are distributed in a radiating manner like the nerves.

THE CEREBRO-SPINAL AXIS.

General Observations.

THE *cerebro-spinal axis* constitutes the *central* portion, whilst the *nerves* form the *peripheral* portion of the nervous system.

The *apparatus of innervation* formed by the cerebro-spinal axis and the nerves together, and named the *nervous system*, is the most important part in the animal machine; it is the source not only of sensation and motion, but of the universal sympathy existing between the several parts of the animal economy; and that part of it called the brain, performs the highest function allotted to organised beings, by becoming the immediate instrument of the soul in the exercise of the intellectual faculties.

The cerebro-spinal axis consists of that soft, pulpy, elongated, and symmetrical mass of nervous substance, which becoming enlarged at its upper part, occupies the vertebral canal and the cavity of the cranium, and forms the centre from which the nerves of all parts of the body take their origin, or in which they all terminate.

The structure of no other organ in the body excites so much curiosity, and unfortunately there is none whose structure is involved in greater obscurity. Notwithstanding the real advances that have recently been made in our knowledge of the anatomy of the brain, we must still acknowledge with Steno, that the human mind, which has carried its investigations even into the heavens, has not yet been able to comprehend the nature of the instrument by which its own operations are performed, and that its powers seem to abandon it as soon as it turns its attention to the organ in which it resides. Until the end of the last century, the study of the central portion of the nervous system consisted in a simple enumeration of its parts, or rather in a more or less imperfect description of its external surface, and of the different objects displayed by various sections. The nomenclature of the different parts of the encephalon † is alone enough to shew with what limited views the researches of those anatomists must have been made, who did not suspect that this pulpy-looking mass, a sufficient definition of which they believed to be, that it held an intermediate place between the solids and the fluids of the body, was as wonderful in the delicacy and intricacy of its structure, as in the importance and elevated character of its functions. In the present day, anatomists include in the study of the encephalon, not only the topographical study of its various constituent parts, but also the determination of the mode in which those parts are connected together. To ascertain this latter point, apart from all questions as to origin, formation, generation, and reinforcement, with which the

* [The nervous filaments proceeding to the utricle and saccule form a fan-like expansion upon those sacs, penetrate into their interior, and spread out as a nervous layer on their internal surface. Each of the nerves which are distributed to the membranous ampullæ appears to bifurcate, so as partially to embrace its corresponding ampulla in a transverse direction; the nervous filaments then penetrate into the ampulla, and spread out upon a transverse septum, formed in its interior by the folding inwards of the walls of the cavity, and also upon the adjacent parts of those walls. (See *Steifensand, Müller's Arch.* 1835.)]

† From ἐν, in, and κεφαλὴ, the head; a convenient term used to signify that part of the cerebro-spinal axis which is situated within the cranium.

subject has lately been embarrassed, should constitute the special aim of every inquiry into the anatomy of this part of the nervous system.

The central portion of the nervous system consists, 1. of the *spinal cord;* 2. of the *tuber annulare*, the *peduncles of the cerebrum and cerebellum*, and the *tubercula quadrigemina;* these together constitute a very constricted portion, which forms the bond of union beween the other parts of the encephalon, and which I shall accordingly name *le nœud de l'encephale* *; 3. of the *cerebellum;* 4. of the *cerebrum.*

The cerebro-spinal axis is surrounded by three membranes or coverings called the *meninges* (from μήνιγξ, a membrane), which perform some important functions in regard to it, and which must in the first place occupy our attention.

THE MEMBRANES OF THE CEREBRO-SPINAL AXIS.

General remarks. — The Dura Mater — the cranial portion, its structure and uses — the spinal portion. — The Arachnoid — its cranial portion — its spinal portion — the sub-arachnoid fluid — their uses. — The Pia Mater — its external cerebral portion.

But few parts of the body are so effectually protected as the cerebro-spinal axis; this protection is afforded in part by the vertebral column †, and by the cranium, the mechanism of which we have already described as being so eminently calculated to defend the parts situated within them.

Besides the osseous case formed by the vertebro-cranial column, we find, surrounding the cerebro-spinal axis, a fibrous sheath, named the *dura mater;* a serous membrane, called the *arachnoid;* and a proper membrane, named the *pia mater*, in which the vessels of the nervous centre ramify.

The Dura Mater.‡

Dissection of the dura mater of the skull. Make either a crucial incision, or one extending from before backwards, or from ear to ear, through the integuments of the head; turn back the flaps, taking care to remove the periosteum with the hairy scalp.

The bones of the cranium being thus exposed, the skull-cap may be removed, either with a sort of hatchet (*marteau-hachette*), or a saw.

This hatchet is the most expeditious and the best instrument. There is no fear of shaking or lacerating the brain if the instrument be properly used; but it is almost impossible to avoid cutting the brain with the saw, the only advantage of which over the other is, that it makes an even section.

The section should be carried quite round the cranium, about a finger's breadth above the orbital arches, the skull-cap being raised and removed by means of the narrow end of the hatchet, or by means of a hook attached to the extremity of its handle.

If the brain is not to be preserved, a somewhat different method of proceeding is adopted. Two parallel cuts must be made with the saw, one on each side of the superior longitudinal sinus along its whole extent. Each of these cuts should then be met by another carried horizontally through the corresponding side of the skull. When the two portions of bone included between these sections are removed, there remains an intermediate portion of bone, about an inch wide, extending from the nasal eminence to the occipital

* [It is necessary to bear in mind that the equivalent term, *nodus encephali*, has been assigned by Soemmerring to the pons Varolii.]

† A vertebrated animal may also be defined to be an animal provided with an encephalon; an invertebrated animal is one having no encephalon.

‡ The application of the term *mater* to the meninges of the brain is derived from the Arabians, who regarded these membranes as the origin or mothers of all the other parts of the body; or perhaps, as Haller has observed, this use of the term depends upon an Arabic idiom, by which the covering of any body whatsoever is called its mother.

protuberance. The dura mater should then be divided along the borders of this intermediate portion of bone, and the brain and cerebellum removed.

If, however, it be intended to preserve the brain and cerebellum, after the entire skull-cap has been removed in the ordinary manner, the dura mater must be divided circularly, along the cut edge of the cranium, the anterior extremity of the falx cerebri must be divided with the scissors, and the whole fibrous cap turned backwards.

Another mode, and one which I prefer, is to make an incision through the dura mater along each side of the superior longitudinal sinus, and then to divide the anterior extremity of the falx, and reflect that part backwards.

Dissection of the dura mater in the vertebral canal. This part of the dura mater may be exposed, either by removing the arches of the vertebræ, or by taking away the bodies of these bones. The latter method is but seldom adopted.

The arches of the vertebræ may be removed by means of a chisel and mallet, or still better by the *rachitome.*

An instrument has lately been invented consisting of two parallel saws, slightly convex on their toothed edges, firmly connected together, but capable of being separated or approximated as may be desired. Preference is justly given to the rachitome over this complicated instrument. The important object in opening the spine is to make the section opposite the junction of the laminæ with the transverse and articular processes.

In order to display the continuity of the cranial and spinal portions of the dura mater, it is necessary to connect the sections already made in the head and spine, by removing with the saw the intervening portion of the occipital bone.

A beautiful preparation of the dura mater may be made by removing the roof and sides of the skull, and the arches of all the vertebræ; by then taking out the encephalon and spinal cord through incisions in the dura mater, which may be readily concealed; and by filling the cavity thus left with tallow, which is afterwards to be dissolved out by spirits of turpentine, or, what is easier to do, the cavity of the dura mater may be filled with fine sand.

The *dura mater* (meninx crassa, *Galen;* le méninge *Chauss.*) is a fibrous membrane which covers and protects the cerebro-spinal axis, and the roots of all the nerves which arise from or terminate in that portion of the nervous system.

It is the most external of the membranes of the brain and spinal cord, (meninx exterior, *Soemmerring*); it consists of a *cranial* and a *spinal* portion.

The Cranial Portion of the Dura Mater.

The *cranial portion of the dura mater* forms a fibrous sac, which lines the internal surface of the bones of the cranium, forming their internal periosteum, and at the same time serves as a covering for the encephalon, and separates its different parts by means of prolongations or incomplete septa.

The dura mater in the skull presents for our consideration an *external* and an *internal surface.*

External Surface of the Dura Mater.

Its *external surface* is accurately moulded upon the internal surface of the bones of the cranium, to which it adheres by a multitude of small fibrous and vascular prolongations, which can be readily displayed by putting the membrane under water. These prolongations give the external surface of the dura mater a rough appearance, which contrasts strongly with the smooth aspect of its internal surface. The ramifications of the middle meningeal arteries and veins are seen on the external surface of the membrane, and project from it, as if they were only laid upon it.

The dura mater adheres to the parietes of the cranium with different degrees of firmness in different situations.

Thus, it is generally less firmly adherent to the roof of the skull than to its base, where it is impossible to separate it from the bone. The upper border of the petrous portion of the temporal bone, the posterior border of the lesser wings of the sphenoid, and the margin of the foramen magnum, are points to which it is very firmly attached; but the dura mater adheres more strongly opposite the sutures than in any other situation. Upon the orbital plates, on the occipital fossæ, and upon the squamous portion of each temporal bone, it adheres so slightly, that it has been conceived to be altogether unattached in those regions.*

The firmness of the adhesion between the dura mater and the bones varies at different periods of life, and also the manner in which it is effected. Thus in old subjects, the parts are so closely united, that it is almost impossible to take off the roof of the skull, without at the same time removing portions of the dura mater. When this happens, there is ossification of the outermost layers of this membrane. In the new-born infant, the adhesion is firmer than in the adult, especially opposite the sutures.

As to the mode in which this adhesion is effected, it may be stated, that in the infant it appears to be exclusively by means of vessels; in old age, almost entirely by fibrous tissue; and in the adult, by partly vascular and partly fibrous prolongations.

The dura mater is moreover attached to the bones of the cranium by means of the fibrous canals formed by this membrane for the nerves and vessels which pass through the foramina in the base of the skull.

The most remarkable prolongations of the cranial portion of the dura mater, excepting that for the spinal cord, are those given off opposite the right and left sphenoidal fissures. Each of these prolongations separates into two layers, one of which forms the sheath of the corresponding optic nerve, whilst the other blends with the periosteum lining the cavity of the orbits.

The Internal Surface of the Dura Mater.

The *internal surface* of the cranial portion of the dura mater appears smoothly polished, and is constantly lubricated with serosity; its polished appearance is owing to a layer of arachnoid with which it is covered: this layer is so thin that one might be disposed to deny its existence, and it is so firmly united to the dura mater that its demonstration is extremely difficult. Excepting at the points where the cerebral veins enter the different sinuses, the internal surface of the dura mater lined by the arachnoid is free, and is in contact with the cerebral arachnoid, and indirectly with the outer surface of the encephalon.

From this surface certain prolongations or imperfect septa are given off, by which the cavity of the cranium is divided into several compartments. These septa are three in number, viz. the *falx cerebri*, the *tentorium cerebelli*, and the *falx cerebelli.*

The falx cerebri. This is a fibrous lamina (*d*, *fig.* 220.), which is placed vertically along the median line, is shaped like a sickle, and extends from the foramen cæcum to the tentorium cerebelli. Its point, which is in front, dips into the foramen cæcum, and envelopes the crista galli; its *base* is behind, and rests perpendicularly upon the middle of the tentorium cerebelli. The venous canal, called the *straight sinus*, is situated along the line in which the falx and the tentorium meet. The *upper border* of the falx is convex, and extends

* An erroneous opinion for a long time prevailed, that the adhesions between the dura mater and the bones were the results of disease; and it has even been believed, that a space existed between the dura mater and the bones of the cranium. These errors resulted from a physiological hypothesis, which attributed the movements of the brain to contraction of the dura mater.

from the foramen cæcum to the internal occipital protuberance. In this border is placed the superior longitudinal sinus.

The *lower border* is concave, thin, sharp, and free, and corresponds to the corpus callosum, touching that body, however, only at the back part, and according to some anatomists, making a rather deep furrow upon it. This free border, which is thicker behind than in front, contains within it a small vein, which has been named the *inferior longitudinal sinus.* The two *surfaces* of the falx correspond to the internal surfaces of the two hemispheres of the brain. Not unfrequently the falx cerebri is found as if torn through in some points, and I once observed the two hemispheres continuous with each other through an opening in this septum.

The use of the falx is evidently to obviate the effects of lateral concussion of the brain, and to prevent one hemisphere from pressing upon the other, whilst the person is lying upon his side.

The tentorium cerebelli. This is an imperfect horizontal septum (le septum transverse, *Chauss.*) which is as it were notched in front, and which separates the cerebrum from the cerebellum. It is constantly in a state of tension; a condition which depends upon the permanently tense state of the falx cerebri. These two parts, indeed, mutually preserve each other's tension, and when either of them is cut, the other necessarily becomes relaxed. It is, therefore, only when the tentorium is examined *in situ*, and the falx is left uninjured, that the anatomy of the former can be properly understood. It is then seen that it represents two planes, inclined upwards, and united in the middle line at an obtuse angle, so as to form a sort of arch, upon the top of which the base of the falx cerebri rests. The concavity of this arch corresponds to and is accurately fitted upon the convex upper surface of the cerebellum below; the convexity corresponds to the slightly concave under surface of the posterior lobes of the cerebrum.

Its *outer* or *convex border* is directed horizontally; it corresponds behind to the posterior portion of the lateral groves, and in front to the upper border of the pars petrosa. The lateral sinus occupies the whole occipital portion of this border.

Its *inner* or *concave border* is parabolic; between it and the basilar groove, in front, a small space is intercepted, which is occupied by the *nodus encephali*, being accurately adapted to that part of the brain. The *extremities* of the external and internal borders cross each other on each side like the letter X: the extremities of the outer border are attached to the posterior clinoid processes, and form on each side a sort of bridge, near the apex of the pars petrosa, beneath which the fifth cranial nerve passes: the extremities of the inner border are prolonged above those of the outer border, and are attached to the anterior clinoid processes. They form the sides of the pituitary fossa, and contain in their substance the cavernous sinuses.

The falx cerebelli. This is a small falciform fold, situated vertically in the median line (le septum médian du ceverlet, *Chauss.*): Winslow remarks that it is sometimes double. It extends from the internal occipital protuberance to the foramen magnum, and separates the two hemispheres of the cerebellum. Its *base*, directed upwards, corresponds with and is attached to the tentorium cerebelli; its *apex* bifurcates upon the sides of the foramen magnum. Its *posterior border* corresponds with the internal crest of the occipital bone, and its *anterior border* with the bottom of the median fissure of the cerebellum.

Structure.

The dura mater is perhaps the thickest and strongest of all the membranous investments of the viscera. It may be regarded as consisting of two very distinct fibrous layers: of an *external* or *periosteal layer*, which forms the internal periosteum of the bones of the cranium, and of an *internal* or *proper cerebral layer*, which though blended with the preceding throughout the greatest part of its extent, is separated from it at certain points, in order to form both the fibrous

canals, which are called the *sinuses*, and also the several folds just described as projecting from the internal surface of the dura mater. Thus, the periosteal layer of the dura mater enters into and lines the longitudinal groove, but the central layer passes off from it on either side; and the two laminæ thus formed by the right and left portions of the cerebral layer approach each other, so as to include between themselves and the periosteal layer lining the groove, a long three-sided interval, which forms the *superior longitudinal sinus.*

The internal layer of the dura mater, which is essentially fibrous, must not be confounded with the arachnoid membrane by which its internal surface is lined, and which will be presently described.

The dura mater is evidently composed of fibrous, not of muscular tissue, as was for a long time believed.*

It consists of fibres which interlace in various directions.

Anatomists generally describe, in connexion with the dura mater, those white granular bodies which are chiefly collected into clusters along the superior longitudinal sinus, and which are improperly called *glands* (the *glands of Pacchioni*, from the name of the author who first gave a good description of them).

These bodies are not found in infants but exist almost constantly in the adult, and are very numerous in old subjects. They are sometimes single and sometimes collected into groups; they are, at first, formed upon the internal surface of the dura mater, but after a time they displace the fibres of the internal layer, and separate them into small, parallel, or reticulated fasciculi, and in this way insinuate themselves between the two layers of the membrane. In this situation they form tumours, which project upon the external surface of the dura mater, and occupy corresponding depressions formed in the bones of the cranium. The rough and irregular depressions, so frequently found in the parietal bones of old subjects, and ascribed by the older anatomists to caries of the bone, are occasioned by the clusters of these granular bodies.

These bodies often insinuate themselves along the obliquely running veins into the substance of the walls of the sinuses, and project into the interior of the veins and sinuses, so as apparently to be in direct contact with the blood; but they are, in reality, separated from that fluid by the lining membrane of the vessels and sinuses.

Although these bodies are principally collected along the superior longitudinal sinus, they are also found, as Haller remarks, opposite the anterior extremity of the straight sinus. I have seen a small pedunculated mass of them, which projected into the interior of the horizontal portion of one of the lateral sinuses, and might have impeded the circulation.

I consider that the bodies in question are seated in the sub-arachnoid cellular tissue; in fact, they are often found beneath the arachnoid, at some distance from the longitudinal sinus, along the superior cerebral veins. They always project at first upon the internal surface of the dura mater, and then insinuate themselves into the substance of that membrane.

What is the nature of these bodies? Ruysch noticed them, and considered them to be of a fatty nature. Some authors have likened them to the granulations so frequently found in the choroid plexuses; but there is not the slightest resemblance between the two. Pacchioni regarded them as glands which secreted a peculiar lymph. He has even described certain, so called, excretory ducts, which have been said by others to enter the superior longitudinal sinus. Those clusters which project into the sinuses have been supposed to act as valves. It has been said that these bodies are lymphatic glands; this also is erroneous; and, indeed, it is better to confess our ignorance

* Pacchioni, who wrote a treatise of some length upon this membrane, even went so far as to admit the existence of three fleshy bellies, viz. one for each hemisphere, and a third for the cerebellum. The same author gives a very minute description of the direction of the different layers of fibres in the dura mater. I do not believe that there exists in the history of our science a more striking example of the misapplication of textural anatomy.

of their nature. They occur so frequently that they cannot be regarded as morbid productions. Their absence in the infant, and their much greater abundance in the old subject than in the adult, are the principal features in their history.

Vessels. In respect of the number and size of its vessels, the cranial dura mater seems to form an exception to fibrous membranes in general, which are remarkable for their slight vascularity. It receives, in fact, the following *arteries* — the middle meningeal, which is a branch of the internal maxillary artery; the anterior meningeal, from the ethmoidal artery; and the posterior meningeal, from the ascending pharyngeal, or pharyngo-meningeal. Nevertheless, if we consider that these vessels are situated between the dura mater and the bones, and that they are almost entirely distributed to the bones, we shall be able to account for the apparent anomaly in the number and size of these vessels.

The *veins* of the dura mater are two venæ comites for each meningeal artery, and the small veins which enter the sinuses; the venous sinuses themselves are situated between the two layers of this membrane.

The *lymphatics* form a network upon the internal surface of the dura mater, but do not appear to belong to the proper fibrous tissue.

Nerves of the dura mater. On consulting the various writers upon this subject, it is found to be involved in the strangest perplexity: some authors admit, whilst others deny in the most positive manner, the existence of nerves in this membrane; and those who do admit their existence, differ altogether in regard to their origin.

Modern anatomists, with Haller, Wrisberg, and Lobstein, state that there are no nerves in the dura mater; on the other hand, Vieussens, Winslow, Lieutaud, Lecat, Valsalva, and others, declare that they have observed them. Valsalva says, that they are derived from the seventh pair; all the other authors state that they arise from the fifth; but they do not agree as to the exact point of origin, which, according to some, is the Gasserian ganglion; and according to others, either the ophthalmic, or the superior or inferior maxillary divisions of that nerve. Chaussier admits their existence, and says that they are derived from the ganglionic system; but it is evident that he has been led to this conclusion from theory, and not from actual observation.

Accident has enabled me most distinctly to demonstrate nerves in the dura mater. In a head which had been macerated in diluted nitric acid, and afterwards in water, the dura mater having become transparent and jelly-like, I was surprised to see within its substance certain white lines exactly resembling nervous filaments. I cut down to these white lines, ascertained that they were nerves, and dissected them throughout their whole course. I recognised on each side of the middle line two nervous filaments which came from the fifth nerves, and reached nearly to the superior longitudinal sinus. There was a third nervous filament in the substance of the tentorium cerebelli, but I could not ascertain its origin.*

Uses of the cranial dura mater. The dura mater serves as an internal periosteum for the bones of the cranium, with which it has numerous vascular connections; and it also covers and defends the encephalon. Its prolongations separate from each other the different parts of the encephalon, and in some measure prevent the effects of concussion. It also contains within its substance certain venous canals, in which all the blood is returned from the encephalon.

The Spinal Portion of the Dura Mater.

The *spinal portion of the dura mater* forms a long fibrous tube, which is prolonged from the cranial dura mater, and extends from the occipital foramen to the termination of the sacral canal.

In order to ascertain the capacity of this fibrous sheath, it must be first dis-

* [The tentorium receives a branch from the fourth cranial nerve (see description of that nerve).]

tended with an injection: it is then seen to form a funnel-shaped tube, which is of considerable size in the cervical region, becomes contracted in the dorsal region, is again expanded in the lumbar region, and terminates in the sacral region by subdividing into a number of sheaths for the sacral nerves. When distended, the spinal portion of the dura mater almost entirely fills the bony canal formed by the vertebral column. Why the cavity of the dura mater (*d*, *fig.* 266. A B) should be larger than the spinal cord (*s*), a question, the solution of which had exercised the ingenuity of almost all anatomists, has been well answered by Cotugno — it is for the purpose of containing a serous fluid.*

The *external surface* of the spinal portion of the dura mater, unlike, in this respect, to the cranial portion, scarcely adheres to the bony parietes of the spinal canal. Covered by a plexus of veins *behind*, it has no attachment at all to the arches of the vertebræ, nor to the yellow ligaments; the intervals between those parts and the membrane is occupied by a soft, reddish, adipose tissue intermixed with veins, which in the fœtus, and during infancy, is infiltrated with serosity. This fat, which is most abundant in the sacral region, may be most aptly compared to the marrow of the long bones, with which it has so much analogy in respect of its use. In one class of vertebrated animals, *viz.* fishes, a precisely similar kind of fat is accumulated in large quantities in the cranium, always filling up the spaces left by the contained organs.

In *front*, the external surface of the dura mater adheres to the posterior common vertebral ligament by fibrous bands, prolonged from it at intervals.

On each *side*, the spinal portion of the dura mater gives off fibrous sheaths (*l*, *fig.* 266.; *b′*, *fig.* 267.) for the roots of the spinal nerves (*n*), which sheaths accompany the nerves beyond the intervertebral foramina, and are lost in the cellular tissue.

The *internal surface* of this part of the dura mater is smooth and moist, in consequence of being covered by a serous layer, viz. the arachnoid (*a*). Down each side of this surface are seen the double orifices of the several fibrous canals, which transmit the anterior and posterior roots of the spinal nerves. It is very rarely found entirely free from adhesions to the arachnoid; and it is necessary to be careful not to confound these adhesions, which are always met with at isolated points, with such as are the result of morbid action.

The *inferior extremity* of the spinal portion of the dura mater is situated opposite the bottom of the lumbar region, and it therefore extends much lower than the spinal cord; this extremity is formed into a large ampulla around the cauda equina, which enlargement seems to be of use only as a reservoir for the cephalo-rachidian fluid.

Its *superior extremity* is firmly attached to the margin of the foramen magnum, and is continuous with the cranial portion of this membrane. In consequence of the firm adhesion of this membrane to the margin of the foramen magnum, and of its attachment to the sacrum by means of the sheaths for the sacral nerves, and to the sides of the vertebral column by those for the cervical, dorsal, and lumbar nerves, it is constantly maintained in a state of tension highly favourable to its use as a protecting covering of the spinal cord.

Vessels. The vessels of the spinal dura mater are much less numerous than those of the cranial portion; for these belong exclusively to it, and not to the surrounding bones.

Its *arteries* arise from the spinal branches of the arteries of the cervical, dorsal, lumbar, and sacral regions. Its *veins* terminate in the intra-spinal veins.

* "Quidquid autem spatii est inter vaginam duræ matris et medullam spinalem, id omne plenum etiam semper est; non medullâ quidem ipsâ in viventibus turgidiori, non nube vaporosâ, quod in re adhuc obscurâ suspicantur summi viri; sed aquâ ei quidem simili, quam circa cor continet pericardium, quæ caveas cerebri ventriculorum adimplet, quæ auris labyrinthum, quæ reliquas tandem complet corporis caveas, libero aeri, nequaquam adeundas." (*De Ischiade Nervosa*, p. 11.)

The *lymphatic vessels* observed, appear rather to belong to the arachnoid.

The *nerves* of this membrane have not yet been demonstrated; but experiments upon living animals, especially upon dogs, have convinced me that the cranial, and probably also the spinal portion of the dura mater, although insensible to the knife, are extremely sensible to laceration.

The Arachnoid.

The cerebro-spinal axis is surrounded by a serous membrane named the *arachnoid*, which, like all membranes of this kind, forms a shut sac, adherent by its external surface, but free and smooth on its internal surface. We shall first describe the *cranial* and then the *spinal portion* of the arachnoid.

The Cranial Portion of the Arachnoid.

Dissection. The arachnoid may be shown upon the convex surface of the brain without any preparation, if the sub-arachnoid cellular tissue be infiltrated. It can also be very easily demonstrated by blowing air under it.

The *arachnoid* membrane, which, from its extreme tenuity, was for a long time confounded with the pia mater, was demonstrated by Ruysch upon the convex surface of the brain by injecting air beneath it; it was shewn by Varolius upon the base of that organ, and its arrangement in that situation was figured by Casserius. It was described first by the Anatomical Society of Amsterdam as a special membrane covering the brain, under the name of the *arachnoid;* and Bichat, reasoning from analogy, demonstrated that it not only forms a covering for the brain, but is also reflected upon the dura mater, and lines it through its whole extent. He also believed that it was continuous with the lining membrane of the ventricles, an error which has been successfully refuted by M. Magendie.

Like all serous membranes, the arachnoid presents a *visceral* and a *parietal layer.*

The Visceral Layer of the Arachnoid.

The *visceral layer of the cranial portion of the arachnoid* requires to be examined upon the convex surface and the base of the brain.

Upon the base of the brain, the arachnoid is separated from this organ in a great number of points, and more particularly as it is passing from one lobe to another. We shall examine in detail the arrangement of this part of the membrane.

In the median line, in *front,* it dips between the anterior lobes of the brain, but only at the fore part; behind, it connects these lobes by passing directly from one to the other; it covers the lower surface of the optic nerves and optic commissure, then the tuber cinereum and the infundibulum, for the latter of which it forms a sheath, and is then reflected above the pituitary body; from the tuber cinereum it passes across to the pons Varolii, leaving a hollow space between it and the brain, which is traversed by a few dense fibrous filaments.

I shall call this space the *anterior sub-arachnoid space;* it may be regarded as the principal reservoir of the serous fluid of the cranium.

In the median line, *behind,* the arachnoid lines the furrow between the posterior lobes of the brain, and is reflected from the corpus callosum upon the superior vermiform process of the cerebellum: at this point it meets with the venæ Galeni, and generally forms a circular fold around them, which was compared by Bichat to the foramen of Winslow in the peritoneum, and which he supposed to be the orifice of an *arachnoid canal,* which opened into the third ventricle beneath the velum interpositum.

The arachnoid covers the whole upper surface of the cerebellum; and having reached the great circumference of that organ, it passes like a bridge from one hemisphere to the other, and from the cerebellum itself to the posterior surface of the spinal cord. In thus passing from one hemisphere of the cerebellum to

the other, and from the cerebellum to the spinal cord, the arachnoid leaves a considerable space or reservoir for serosity, which may be called the *posterior sub-arachnoid space.*

Laterally, the arachnoid covers the inferior surface of the anterior lobes of the cerebrum and the olfactory nerves, which are thus held in contact with the anterior lobes; it then passes from the anterior to the posterior lobe, without entering the fissure of Sylvius, and from the posterior lobe to the tuber annulare and the cerebellum. It follows, therefore, that there are certain small sub-arachnoid spaces, which communicate with the great anterior sub-arachnoid space of the brain; so that in the dead body there exists between the arachnoid and the pia mater, at the base of the brain, a large space, the centre of which corresponds to the median excavation of the base of the cerebrum, and which is prolonged forwards between the anterior lobes of the brain, laterally along each of the fissures of Sylvius, and backwards around the peduncles of the cerebellum. By this last-named prolongation a communication is established between the anterior and posterior sub-arachnoid spaces. All these spaces contain serum in the natural state, and coagulable lymph in some cases of inflammation of the sub-arachnoid cellular tissue.

The arachnoid is arranged in an uniform manner in reference to all the nerves situated at the base of the brain; it passes over their lower surface, and therefore holds them firmly against the under surface of the brain; but where these nerves are separated from the brain, it furnishes a tubular prolongation around each, and again leaves them as they are about to enter the foramina in the base of the skull, and is reflected upon the dura mater.

Upon the upper surface of the brain, the arachnoid dips into the median fissure, and is reflected from one hemisphere to the other immediately below the free margin of the falx cerebri; and as this margin is nearer to the corpus callosum behind than in front, it follows that the anterior portions of the two hemispheres are in contact with each other for a certain distance, or rather they are merely separated by the pia mater.

The cerebral arachnoid adheres intimately to the arachnoid of the dura mater, along the sides of the superior longitudinal sinus, by means of the tubular prolongations which it forms around the cerebral veins that enter that sinus. This adhesion is also strengthened by the granular bodies, called the glands of Pacchioni, which, as we have already stated, lie in the substance of the dura mater.

Moreover, on the convex surface, as well as upon the base of the brain, the arachnoid, in covering this organ, passes like a bridge from one convolution to another, never dipping into the intermediate sulci.

The cellular tissue, which unites the arachnoid to the pia mater, is of a serous nature and extremely delicate, so that the two membranes can be easily separated, excepting in cases of inflammation. When air is blown beneath the arachnoid, the extreme tenuity of this cellular tissue becomes evident; it is very frequently infiltrated with a serous fluid.

The sub-arachnoid cellular tissue never contains any fat. The fat which Ruysch, Haller, and other anatomists say they have observed, must have been that yellowish gelatiniform lymph, so commonly met with in cases of inflammation.*

In some parts the arachnoid is lined by fibrous tissue, which gives it great strength. This fibrous tissue, which may be regarded as a prolongation of the neurilemma of the spinal cord, is especially distinct in the great furrows of the brain. Thus we find it around the great anterior sub-arachnoid space, where it constitutes, as it were, a very strong fibrous band, which surrounds the arterial circle of Willis, situated at the base of the brain; it also retains the different parts of the brain in their relative positions, even when that organ is removed from the cranium, and is laid with its base uppermost.

* I once found in an old woman an adipose cyst, about the size of a small grape, arising by a very thin pedicle from the upper surface of the pituitary body.

The Parietal Layer of the Arachnoid.

The internal surface of the dura mater is lined with a very delicate and closely adherent serous membrane, which, owing to these two qualities, for a long time escaped the notice of anatomists. It was only by reasoning analogically from the structure of all other serous membranes, that Bichat was led to enter upon the inquiry which ended in the discovery of the parietal portion of the arachnoid. This portion is quite distinct from the internal layer of the dura mater, the existence of which we have admitted with several anatomists. Upon a mere inspection we should say, that it does not exist, because, from its transparency, the fibrous bundles of the dura mater can be seen as distinctly as if they were not covered. But if a very superficial incision be made upon the inner surface of the dura mater, some extremely thin shreds may be detached by the aid of the forceps. Lastly, ecchymosis not unfrequently occurs between the dura mater and the arachnoid.* Ossific deposits in the dura mater, especially those found in the falx cerebri, being found beneath the arachnoid, sometimes enable us to detach this latter membrane in the most distinct manner.

It still remains, however, to describe the mode in which the parietal and cerebral portions of the arachnoid become continuous with each other. It has been stated that the arachnoid membrane forms tubular prolongations around each of the nerves, which are given off from the base of the brain, and around each of the veins which enter the different sinuses: these prolongations just enter the fibrous canals formed by the dura mater for these nerves and veins, and almost immediately terminate by being reflected upon the dura mater itself; so that the arachnoid forms a sort of cul-de-sac around the cranial orifice of each fibrous sheath of the dura mater. In order to see the funnel shaped prolongations of the arachnoid, it is convenient to examine them when the brain is being lifted up from before backwards, in order to expose and divide the nerves which are attached to the base of the skull. The tubular prolongations being then dragged upon, they become very distinct. Not unfrequently the developement of adventitious false membrane on the base of the brain also extends along these prolongations.

The arachnoid does not enter into the interior of the ventricles, below the posterior border of the corpus callosum. The arachnoid canal, called the canal of Bichat, does not exist; but it is formed by the very experiment made to demonstrate it. The following is the statement of Bichat regarding this alleged canal: —

"The brain being exposed from behind and allowed to remain in its natural position, the back part of each posterior lobe is to be raised, and drawn gently outwards; the venæ Galeni are then seen emerging from the canal by which they are embraced, and the oval orifice of which is now very apparent. Sometimes, however, the margin of this orifice embraces the veins so closely, that it can only be recognised by a small fissure on each side, and the parts at first sight would appear to be continuous. If a probe be then glided from behind forwards along these vessels, and when it has penetrated a short distance, *if it be turned all round the veins, it will destroy the adhesions, and the opening will become very evident.*

"In order to be convinced that this opening leads into the middle ventricle of the brain, a grooved director must be introduced, below the venæ Galeni, and pushed gently forward: it will enter the ventricle without difficulty. The corpus callosum and the fornix are then to be removed, and the velum interpositum left untouched. Next dividing the velum on the director, the membrane will be found to be smooth and polished in the whole of its course, and

* As to the collections of blood which are said to have been met with between the arachnoid and the dura mater, M. Baillarget has clearly shown, in several preparations which he presented to the Anatomical Society, that the supposed layer of arachnoid is a newly formed membrane, having all the appearances of a serous membrane.

no where lacerated by the introduction of the director. *Occasionally some resistance is experienced to the entrance of the director, which may even be completely arrested: this depends upon the fact, that the veins which enter the venæ Galeni interlace in all directions within the canal, so as to form a network, which arrests the instrument.* If this be the case, it should be withdrawn, and in order to demonstrate the communication, some mercury should be poured into the external opening, and by inclining the position of the head, this fluid will flow into the middle ventricle. Air blown into the canal will also enter that ventricle, and will pass from it into the lateral ventricles, through the openings, behind the anterior pillars of the fornix. If the fornix be removed, and the velum be exposed, the latter will be seen to be elevated each time that the air is blown in.

"The internal orifice of this communicating canal is at the lower part of the velum interpositum; in order to see it, this membrane must be reflected backwards, either with the fornix, the under surface of which it covers, or after it has been separated from that part of the brain. The pineal gland which adheres to the velum is also to be turned back; below and in front of this gland, is then seen a row of cerebral granulations, arranged in the form of a triangle, having its point turned forwards. The internal orifice of the canal of the arachnoid is at the base of this triangle."

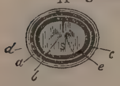
Now, if we make the dissection described by Bichat, it is easy to see that there exists at the back part of the brain, below the corpus callosum, a circular or oval opening, leading into a sort of cul-de-sac, which is of variable depth, and is formed by the reflection of the arachnoid around the venæ Galeni: it is seen also that the bottom of this cul-de-sac may be easily lacerated by a blunt probe, which may then be passed beneath the velum interpositum, as Bichat has pointed out; but it is through an artificial canal. Moreover, if a coloured liquid be injected into the ventricles, it can never be made to escape through this imagined canal of Bichat; and so, on the other hand, if a liquid be thrown into the orifice of this canal, it never enters the third ventricle: mercury enters only by lacerating the parts; and the same is the case with air. Analogy, which has so often conducted Bichat to beautiful and grand discoveries, has therefore misled him in this particular.

Since then the arachnoid canal of Bichat does not exist, it will be necessary to determine how the ventricles communicate with the external arachnoid cavity. This question we shall discuss presently.*

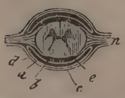
The Spinal Portion of the Arachnoid.

The spinal cord, besides its own proper investment, is covered by a transparent membrane of extreme tenuity, and only to be demonstrated properly by raising it with the forceps, or by subjecting it to the mode of preparation above described: this is the *visceral layer of the spinal portion of the arachnoid.*

A *Fig.* 266.



B



This *visceral layer* (*b*, *fig.* 266. A B) forms a membranous sheath, which is much larger than the spinal cord (*s*); hence it is named the *loose arachnoid.* It is prolonged around the bundle of nerves called the *cauda equina*, and forms around each nerve a funnel-shaped sheath, which terminates in a cul-de-sac at the corresponding intervertebral foramen, by being reflected upon the inner surface of the fibrous sheath formed for the nerve by the dura mater (see *fig.* 266. B).

There exists then, between the spinal cord and the visceral portion of the arachnoid, a considerable space (*e*, *fig.* 266. A B), which can be best displayed by inflating it, or injecting it with some liquid. This space, as we shall immediately shew, contains a serous fluid.

* [The existence of the canal of Bichat is admitted by Arnold, a recent authority. Perhaps the opposite statements of anatomists concerning this canal may depend on the fact, that the canal itself, though originally present, is sometimes closed subsequently, and at other times remains open.]

We have seen that, opposite the median excavation at the base of the brain, the arachnoid adheres to the cerebral pia mater only by means of long fibrous filaments. The spinal arachnoid also adheres to the proper covering of the cord by means of fibrous filaments; but in no part does there exist any delicate sub-arachnoid cellular tissue, like that found beneath the cerebral arachnoid.*

Another peculiarity in the visceral layer of the spinal portion of the arachnoid is this, that it adheres to the parietal layer in a number of points.

The *parietal layer* (*a*) of the spinal portion of the arachnoid is arranged precisely in the same manner as the parietal layer of arachnoid in the skull. It becomes continuous with the visceral layer opposite the sheaths which are formed by the latter around the spinal nerves.

The Sub-arachnoid Fluid.

There exists around the spinal cord a serous fluid, in quantity sufficient to occupy the interval left between the cord and the dura mater: this fluid is seated in the sub-arachnoid space. (*e*) A similar fluid exists in the ventricles of the brain and in the sub-arachnoid cellular tissue, and fills the free spaces of the cranial cavity.*

The existence of the sub-arachnoid fluid was pointed out by Haller (*Elementa Physiologiæ*, t. iv. 87.), and most explicitly and completely demonstrated by Cotugno (*De ischiade nervosâ commentarium*), but the fact was neglected by anatomists, and the fluid regarded by some as the result of cadaveric exudation, and by others as that of a morbid action. The existence of this fluid has been again confirmed by M. Magendie, who moreover has clearly proved, that it is seated in the sub-arachnoid tissue.

In order to prove the existence of the sub-arachnoid fluid, or cephalo-rachidian fluid of Magendie, it is necessary to open the lumbar region of the spinal canal in a certain number of subjects. If an incision be very carefully made through the dura mater, it will be seen that the serous fluid raises the visceral layer of the arachnoid, so as to make it protrude like a hernia through the incision: if this layer of arachnoid be then divided, the liquid will escape. Cotunni, who performed this experiment upon twenty subjects, collected from four to five ounces of fluid in each case.

To the objection that this fluid is found after death, but does not necessarily exist in the living subject, we may answer thus: — There is a space between the spinal cord and the dura mater, and the brain itself does not exactly fill the cranial cavity. Now, in no part of the animal body does there exist any vacuum; the spaces between the solids are always filled either with liquids or gaseous fluids. But if it be said that in this situation the space is filled by a serous vapour, the elasticity of which might establish an equilibrium with the external air, it may be replied that this vapour would not be sufficient to produce so large a quantity of fluid as is found in the spinal canal.

Moreover, all these objections, and also the supposition that the brain and spinal cord may be smaller after death than during life, are overthrown by the following experiment. If the posterior cervical muscles be divided in a living dog, at their occipital attachments, the posterior occipito-atlantoid ligament will be exposed. The parts being well cleansed from blood, the ligament must be cut away, layer by layer, with a scalpel held flat against it. The ligaments

* [The spinal sub-arachnoid space is divided behind by a thin and in some parts cribriform longitudinal septum, which extends from the loose arachnoid to the posterior median fissure of the cord. This space is probably lined throughout by a serous membrane, which contains the rachidian fluid, and which might be named the *internal arachnoid*. The septum just mentioned may be supposed to consist of two layers of this membrane reflected from the loose arachnoid to the cord, and having the same relation to it as the mesentery has to the intestine; and the membrane itself may be conceived to be prolonged through the foramen described by Magendie at the bottom of the fourth ventricle (see p. 960.), so as to form the lining membrane of the fourth, third, and lateral ventricles; and, further, in case of the existence of the foramen of Bichat, to become continuous with the external or true arachnoid through that foramen.]

will scarcely be cut through, before a small hernial protrusion containing a fluid will be seen; this consists of the visceral arachnoid raised by the rush of fluid. If a crucial incision be then made in the occipito-atlantoid ligament by the aid of a director *, a fluid as limpid as distilled water will be seen beneath the visceral layer of the arachnoid, which fluid is agitated by two kinds of motion, one of which is isochronous with the pulse, and the other with the respiratory movements. If the arachnoid be next punctured, the fluid will immediately escape in jets, and its quantity may be ascertained.

The difficulty of not wounding the visceral layer of the arachnoid explains why, until recently, it was thought that the spinal fluid was contained within the arachnoid cavity (*c*, *fig.* 266.), *i. e.* between the two layers of the arachnoid membrane, although most observers had noticed that the serous fluid in the cranium occupied the sub-arachnoid cellular tissue. It follows, therefore, that besides the fluid which is exhaled from the free surface, *i. e.* into the cavity of the arachnoid, a certain quantity of a similar fluid fills up the areolar tissue of the sub-arachnoid space: in this respect the arachnoid differs essentially from other serous membranes, all of which pour their secretions into their cavities, and not into the subjacent cellular tissue.

This peculiarity depends simply upon the non-adhesion of the arachnoid to the spinal cord; it may be stated as a law, that serous membranes exhale almost indifferently from either their internal or their external surface, when the latter surface is not adherent. The arachnoid exhales a fluid from both surfaces; a certain quantity of fluid is rather frequently found between its two layers; and although in acute inflammations the deposit of purulent matter or of false membranes most generally takes place in the sub-arachnoid cellular tissue, yet these morbid products are not unfrequently found in the cavity of the spinal arachnoid itself.

The sub-arachnoid fluid exists not only in the vertebral canal, but also within the cranium, in which it fills up all the spaces between the brain and the dura mater.

Now, these spaces are subject to much variety in size in different individuals, or from age or from disease: thus, in atrophy of the brain and spinal cord, from old age or disease, the interval between the dura mater and the cerebro-spinal axis is augmented, and the quantity of fluid increases in the same proportion.

The quantity of the sub-arachnoid fluid is in a direct ratio with the progress of age; in aged lunatics, in whom the convolutions of the brain are much atrophied, the quantity of this fluid contained within the cavity of the cranium is very great.†

The sub-arachnoid fluid in the cranium is not distributed equally around the brain, but is chiefly seated at its base. In order to show this fluid, it is merely necessary to raise up the brain carefully from before backwards, when it will be seen distending all the funnel-shaped prolongations formed by the arachnoid around the nerves, and it will escape as soon as the membrane is divided.

As regards quantity, the sub-arachnoid fluid at the base of the brain and the fluid of the ventricles are always directly proportioned to each other, but are inversely proportioned to the sub-arachnoid fluid upon the convex surface of the brain. Upon opening the head of infants who have died from acute ventricular hydrocephalus, we sometimes find the convex surface of the brain

* It is highly important to make the transverse incision very short, in order to avoid injuring the very large vertebral veins; for if these vessels be cut, the hæmorrhage will be so abundant as to prevent the continuation of the experiment.

† None of these facts escaped the notice of Cotugno.

"Nec tantum hæc aqua complens ab occipite ad usque imum os sacrum, tubum duræ matris . . . sed et in ipso redundat calcariæ cavo omniaque complet intervalla quæ inter cerebrum et duræ matris ambitum inveniuntur . . . . quantum autem magnitudinis cerebrum in his perdit, tantum a contactu subtrahitur duræ matris, et quidquid loci decrescendo reliquit, aquosus vapor collectus lotum adimplet." (*Op. cit.* p. 11, 12.)

dry, and as it were adhesive. It is of importance to determine whether the cavities containing the cephalic and the spinal fluids communicate with each other. There can be no doubt that the sub-arachnoid spaces of the brain communicate with the sub-arachnoid space around the spinal cord; but do the cavities of the ventricles communicate with the sub-arachnoid space?

Haller admitted that the fluid could flow from the ventricles into the spinal canal, and he believed that this was effected by a communication between the ventricles and the cavity of the arachnoid itself.* Cotugno expresses the same opinion still more distinctly. Both Haller and Cotugno † thought that this communication occurred at the bottom of the fourth ventricle, but they neither indicated the exact situation, nor the mode in which it is effected. M. Magendie has pointed out that it occurs at this very spot, near the point of the *calamus scriptorius*. Bichat stated that the communication between the ventricles and the arachnoid cavity was at the so-called canal of Bichat. The mode in which the fourth ventricle communicates with the sub-arachnoid space will be much better understood if stated in our description of that ventricle. ‡

Uses of the Arachnoid and of the Sub-arachnoid Fluid.

Uses of the arachnoid. Like all serous membranes, the essential use of the arachnoid is to lubricate the surface of the brain and spinal cord, and thus facilitate their movements. No other membrane more completely fulfils such a use, for the arachnoid is moistened in both its external and internal surfaces. It would, in fact, be an error to suppose, that the serous secretion is poured out solely by that surface of the arachnoid which is turned towards the pia mater: the fluid is exhaled upon its internal surface also, as in all other serous membranes, so that we sometimes find serum, pus, and false membranes in the cavity of the arachnoid itself.

Uses of the arachnoid fluid. The sub-arachnoid fluid forms a sort of bath around the spinal cord, which effectually protects it during the various motions of the vertebral column. It might be said that the spinal cord, being, in reference to its delicacy, in conditions somewhat analogous to those of the fœtus in utero, requires a similar method of protection; and in this point of view the sub-arachnoid fluid exactly represents the liquor of the amnios.

As to the other uses which have been attributed to it, they are all more or less hypothetical.

If we open the spinal canal of a dog, between the atlas and the occipital bone, some fluid will immediately gush out; air is drawn in, which is forced out in bubbles during expiration, and again enters during inspiration. If the animal be then left to himself, he will stagger like a drunken man; he will crouch into a corner, and remain in a drowsy state for some hours. On the next day, he will walk about again perfectly well. I have repeated this operation several times upon the same dog, until at last he became accustomed to it, at least as far as regards the physiological effects resulting from the removal of the fluid, by which means the slight pressure usually exercised upon the spinal cord was removed.

The Pia Mater.

The *pia mater* is the innermost of the three membranes of the encephalon and spinal cord. It consists of an extremely delicate membrane, or rather of a vascular network, which immediately invests the nervous axis, and which may

* "Qua prodit de ventriculo aqua, facili in medullæ spinalis circumjectum spatium etiam parat; eam aquam enim difficulter omnino in tertium ventriculum et ad infundibulum redderet, quoad perpendiculum oportet ascendere (*Haller*, tom. iv. sect. 3. p. 77.) . . . Non dubito quin collecta ex ventriculis cerebri aqua eo descendere possit." (*Ibid.* sect. 3. p. 87.)

† "His spinæ aquis eas etiam subinde commisceri, quas, sive a majoribus cerebri ventriculis per lacunar et Sylvii aqueductum, sive a propriis exhalantibus arteriis, cerebelli ventriculus accipiat; cujus positio perpendiculata et via ad spinæ cavum satis patens defluxum humoris in spinam manifesti persuadent." (*Cotugno*, p. 18, 19.)

‡ See note, p. 920.

be regarded as the nutritious membrane of the parts that are covered by it. In fact, the arterial vessels divide into an infinite number of branches within this membrane, before they enter the nervous substance, and so also the veins which pass out from the brain and spinal cord unite into small, and then into larger vessels, which form part of this same network. These vessels are supported by a very delicate serous cellular tissue: to this is added, in some regions, a certain amount of fibrous tissue, which converts the membrane into a very strong fibrous structure, having all the characters of the neurilemma, or proper investment of the nerves.

The characters of the spinal portion of the pia mater are so distinct from those of the cranial portion, that it will be better to postpone the description of the former until we are treating of the spinal cord, of which it constitutes the proper covering.

The Cranial Portion of the Pia Mater.

This portion, or the *cerebral pia mater*, does not merely inclose the brain like the arachnoid, but dips into the sulci or anfractuosities on its external surface, and penetrates into the interior of the ventricles. That portion of the pia mater which invests the brain is called the *external pia mater*, and that which is continued into the ventricles is denominated the *internal pia mater*.

The internal pia mater cannot be satisfactorily studied until the internal conformation of the brain is understood, and it will therefore be described together with the ventricles.

The External Cerebral Pia Mater.

Dissection. At the base of the brain, the pia mater is naturally separated from the arachnoid by a considerable space, which is occupied by the sub-arachnoid fluid; but it is easy to separate these two membranes everywhere by introducing air or water between them. The arachnoid may be easily distinguished from the pia mater in cases of serous or purulent infiltration into the sub-arachnoid cellular tissue.

The *external pia mater* is subjacent to the arachnoid, and is connected with it by a very delicate serous cellular tissue; it not only covers the free surface of each convolution, but also dips into the adjacent sulci; it passes down on one side of a sulcus, and then being reflected upon the other, is continued over the free surface of the next convolution, and so on. It follows, therefore, that this part of the pia mater is in contact with itself to a great extent; and also that its superficies is much larger than that of the arachnoid, so that if the brain could be unfolded, as Gall supposed, its surface would be entirely covered by the pia mater. These remarks apply equally to the pia mater of the cerebellum, for every one of the numerous laminæ of that organ is covered on each side by a fold of the pia mater.

The internal surface of the pia mater is in contact with the brain, and is united to it by innumerable vessels, which penetrate into the substance of that organ. This adhesion, however, is such, that the pia mater can generally be detached without injuring the surface of the brain.

I do not think, however, with some pathologists, that the adhesion of this membrane to such a degree that it cannot be removed without injuring the substance of the brain, is any evidence of disease.*

For displaying the vessels which pass into the substance of the brain from the pia mater, an asphyxiated subject is very well adapted. But an injected condition of these vessels may be produced by allowing the head of the subject to hang down for some hours. The pia mater will then be not only black from its congested state, but it will be infiltrated with serum; and if it be de-

* In some cases the membranes are so dry that the pia mater cannot be removed without tearing the substance of the brain, even when that organ is perfectly healthy.

tached slowly, an immense number of vascular filaments, looking like hairs, will be seen emerging from the substance of the brain, remarkable for their extreme tenuity and length, and for having no anastomoses. Some drops of blood will indicate the points upon the surface of the brain, from which the vessels escape, and which, when examined through a lens, prove to be foramina.

The *use* of the pia mater is connected solely with the circulation of blood through the brain. This membrane affords to the vessels a very large surface, on which the arteries divide into their capillary branches, and the veins unite into their larger and larger trunks. According to my observations, five-sixths of the vessels of the pia mater belong to the venous system.

The pia mater is the nutritious membrane of the brain, and may thus be regarded as its neurilemma.

It will afterwards be seen that the internal pia mater is connected with the arteries and veins of the walls of the ventricles, just as the external pia mater is with the external vessels.

THE SPINAL CORD, AND THE MEDULLA OBLONGATA.

General view of the Cord — its limits and situation — the ligamentum denticulatum. — Size of the Spinal Cord — form, directions and relations — the Cord in its proper membrane — the proper membrane, or neurilemma of the Cord — the Cord deprived of its proper membrane. — Internal Structure of the Cord — sections — examination by means of water — and when hardened in alcohol — the cavities or ventricles of the Cord. — The Medulla Oblongata — situation — external conformation — anterior surface, the anterior pyramids, and the olivary bodies — the posterior surface — the lateral surfaces — the internal structure — sections — examination by dissection, and under water. — Developement of the Spinal Cord. — Developement of the Medulla Oblongata. — Comparative anatomy of the Spinal Cord. — Comparative anatomy of the Medulla Oblongata.

THE *spinal cord* (*μυελὸς ῥάχιτης, medulla spinalis; a b c, fig.* 268.) is that white, roundish, symmetrical, nervous trunk, which occupies the spinal canal; it is continuous with the encephalon, of which it has been alternately considered the origin and the termination. It is called the *medulla*, in consequence of a rude analogy between it and the marrow of the long bones, in regard to its situation and consistence. Chaussier has substituted for this term the title of *rachidian prolongation*, but the generally received name of spinal marrow, which can give rise to no error, might be retained.*

The Extent and Situation of the Spinal Cord.

Authors are not agreed as to the superior limit of the spinal cord. The natural limit is evidently at the groove, between the medulla oblongata (*a, fig.* 268.) and the pons Varolii (*e*), which groove, on account of the great size of the pons in man, is much more distinctly marked in him than in those vertebrated animals in which the pons is also found.

The spinal cord is *situated* in the median line, at the back part of the trunk; it is behind the organs of digestion, circulation, and respiration. †

* The first description of the spinal cord, which is worthy of notice, was given by Huber (*J. Huber, de Medullâ Spinali.* Goettingæ, 1741) — it served as the basis for the works of Haller (*Elem. Physiol.* tom. iv. sect. 1.); of Mayer, who published a beautiful plate of it in 1779; and perhaps of Alexander Monro, Secundus (*Observations on the Structure and Functions of the Nervous System.* 1783). Soemmerring, Reil, and Gall, who so successfully studied the other parts of the nervous system, have noticed the spinal cord in a superficial manner. Chaussier (*De l'Encephale en général et en particulier*); Keuffel, in his inaugural dissertation (*De Medullà Spinali*, 1810, dedicated to Reil, his preceptor); and Rolando (*Richerche Anatomiche sulla Struttura del Midollo Spinale.* Torino, 1824), have supplied many of the deficiencies in our knowledge of this part. There is a good description of the medulla in M. Ollivier's work upon the diseases to which it is subject.

† The position of the nervous axis *behind* the alimentary canal constitutes one of the great differences which exist between the nervous system of the vertebrated and the invertebrated animals; in the latter, the nervous system lies below, *i. e.* in *front* of the alimentary canal.

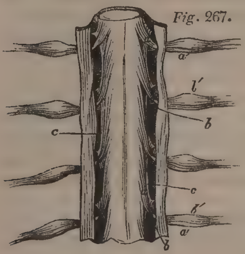
The vertebral column, the dura mater, the arachnoid, and the pia mater form a fourfold sheath for the spinal cord; the first being osseous; the second, fibrous; the third, serous; and the fourth, or proper sheath, both fibrous and vascular: this last-named membrane is accurately adapted to the cord, so as to support it, and gently compress it on all sides.

The spinal cord is not suspended freely in the vertebral canal, but is attached on each side by a ligament, called the *ligamentum denticulatum.*

The Ligamentum Denticulatum.

The *ligamentum denticulatum* (*c c*, *fig.* 267.), so called from the toothlike prolongations which proceed from its outer border, is an extremely slender, fibrous band, which runs along the side of the spinal cord, and adheres to the proper sheath of the cord by its inner border, which is very thin. The outer edge is free, thicker than the inner portion, and gives off certain toothlike prolongations, which are attached to the dura mater in the intervals between the canals formed by that membrane for the spinal nerves: the first denticulation of this ligament, which may be regarded as its origin, is very long, and is found opposite the margin of the foramen magnum, between the vertebral artery and the hypoglossal nerve; the last, which is the twentieth or twenty-first, forms the termination of the ligament, and corresponds very nearly to the lower extremity of the spinal cord. The form, thinness, and length of these toothlike processes are subject to much variety.

Fig. 267.



The ligamentum denticulatum is evidently fibrous, and cannot be regarded, as Bonn imagined, as a prolongation of the arachnoid.*

The ligamentum denticulatum appears to answer the twofold use of assisting in fixing the spinal cord, and of separating the anterior (*a*) from the posterior (*b*) roots of the spinal nerves.

The Dimensions of the Spinal Cord.

The length of the spinal cord in the adult is from fifteen to eighteen inches. Its circumference is twelve lines at the thinnest part, and eighteen at the thickest. But it is of much less importance to determine the actual dimensions of the spinal cord, than to estimate its relative size as compared with that of the brain, or in reference to the capacity of the vertebral canal, or than to examine the differences in size which it presents at different parts of its extent.

If the size of the spinal cord be compared with that of the whole body, throughout the series of vertebrated animals, we shall perceive that it always bears a direct ratio to the vital activity of the animal. Thus considered, the spinal cord is small in fishes and reptiles, and large in birds and the mammalia.

Size and weight of the spinal cord compared with the size and weight of the brain. It was whilst studying the spinal cord and the brain in serpents and fishes, that Praxagoras, as quoted by Galen, originated the idea that the brain was a production of the spinal cord. All the old anatomists, on the other hand, who studied the brain and cord in man, in mammalia, and in birds, regarded the medulla spinalis as a prolongation, or appendix of the brain (tanquam cerebri effusionem, *Rufus*); indeed, it was for a long time considered that the medulla

* It is idle to inquire, whether it should be considered a prolongation of the dura mater, or an extension of the neurilemma, or a proper ligament.

was the principal nerve in the body, *summus in corpore humano nervus.* In the present day, anatomists have returned to the opinion of Praxagoras, and the spinal marow is generally regarded (Reil, Gall, Tiedemann) as the fundamental part of the nervous system, and that the brain is merely a production, an appendage, or an expansion of the cord. I shall not here enter into these purely speculative questions of production or emanation, origin, and relative importance, for the spinal cord no more produces the brain, than the brain produces it.

Soemmerring has shown that, in man, the spinal cord is smaller in proportion to the size of the encephalon than in the lower aninals; and of this there can be no doubt; but it does not follow that the lower animals have a larger spinal cord than man, in proportion to the size of their bodies: on the contrary, from actual observation I should say, that, if we except birds, man has a relatively larger spinal cord than any other animal. Compare, indeed, the medulla of the horse, or of the ox, with that of man, and it will at once be found that the last is the largest and heaviest in proportion to the rest of the body.

According to Chaussier, the weight of the spinal cord in the adult is from the nineteenth to the twenty-fifth part of that of the brain, and in the new-born infant about the fortieth part. According to Meckel, this last is also the proportion in the adult. It must be remembered, however, that Meckel examined the cord when deprived of its proper membrane, and, therefore, after the roots of the nerves were detached from it.

Size of the spinal cord compared with the capacity of the spinal canal. The spinal cord does not by a great deal fill up the vertebral canal, and a considerable interval occupied by fluids exists between it and the sides of the canal. What is the object of this disproportion? and why is there any interval? We have already stated (see OSTEOLOGY), that the dimensions of the canal are in relation, not only with the size of the cord, but also with the extent of motion of the vertebral column. The opinion of Vieussens, that this space is intended to allow of certain movements of elevation and depression in the spinal cord, analogous to those which have been observed in the brain, is sufficiently refuted by the fact, that, although the latter organ is affected by movements synchronous with the respiration and with the pulse, it still fills the cavity of the cranium. *

The *length* of the spinal cord does not correspond with that of the vertebral canal, for the cord terminates near the first lumbar vertebra (between 20 and 21, *fig.* 268.), whilst the canal is prolonged into the sacrum.

The position of the *lower end* of the spinal cord has not been determined with the precision which so important a question demands. According to Winslow, it terminates opposite the first lumbar vertebra; Morgagni has seen it reach down to the second; Keuffel has observed it to descend as low as the third lumbar vertebra in one subject, and to terminate opposite the eleventh dorsal vertebra in another. The discrepancy between various authors upon this subject, depends upon individual varieties in the point of termination of the cord, and upon the different acceptation of the term lower extremity of the spinal cord; some regarding the thick swollen part as the end of the cord, whilst others include in it the tapering portion also. From some experiments which I made upon this subject, by thrusting a scalpel horizontally from before backwards,

* From several experiments which I have made upon this subject, it appeared that the spinal fluid seen (confined in its membranes) in the cervical region between the occipital bone and the axis, was agitated by movements synchronous with the pulse and the respiration; but that when this fluid had been evacuated, the spinal cord did not move at all. I have examined with the greatest care the tumours existing in the lumbar region in infants afflicted with spina bifida; I could never detect in them any movement corresponding with the pulse, but the movement of respiration exerted a manifest influence upon them: thus, when the sac was emptied by compression, the cries of the infant, excited by pain, were almost instantly followed by extreme tension of the sac. As the spinal cord is not affected by the great arteries at the base of the brain, it cannot participate in the slightest degree in those movements which are observed in the spinal fluid at every pulse of the heart, and which are communicated to that fluid by the cerebral arteries.

through the intervertebral substance between the first and second lumbar vertebræ, I ascertained that there are varieties in different subjects in regard to the point of termination of the spinal cord, and that it was influenced by the position of the body, and by the state of flexion or extension of the head and spine, but that in general, the widest part or base of the cone in which the cord ends, corresponds to the first lumbar vertebra, and the apex of the cone to the second.

During the early periods of fœtal life, the cord descends as low as the sacrum, but in fœtuses at the full time, I have never found so marked a difference as has been described by some modern anatomists.*

Differences in the size of the spinal cord at different points of its extent. The spinal cord is not of uniform dimensions throughout its whole extent: it is much enlarged at its upper part, opposite the basilar groove, where it constitutes the *superior* or *occipital rachidian bulb*, or the *medulla oblongata*, (*a*), it becomes narrowed immediately after having emerged from the foramen magnum. This constriction, which is named the *neck of the rachidian bulb*, is regarded by many anatomists as the commencement of the spinal cord.

Another oblong enlargement, extending over a much greater length than the preceding, and named the *middle*, *cervical*, or *brachial rachidian bulb*, or *cervical enlargement* (*b*), commences opposite the third cervical, and terminates opposite the third dorsal vertebra.

The spinal cord again becomes considerably contracted from the first to the eleventh dorsal vertebra, and then presents a third enlargement of less extent than either of the other two, constituting the *inferior lumbar* or *crural rachidian bulb*, or *lumbar enlargement* (*c*), it then immediately tapers like a spindle, and terminates in an exceedingly slender semi-transparent cord, which has a fibrous, filiform aspect, is concealed amongst the nerves of the cauda equina (*d*), and is always accompanied by a vein. This cord may be distinguished from the surrounding nerves by its being situated in the median line, and by its thinness, its fibrous character, and its termination. It may be traced as far as the base of the sacrum, when it terminates in the dura mater.

In some cases the narrow portion of the inferior rachidian bulb, is bifurcated, but the two branches of the bifurcation terminate in a single fibrous cord. Huber, Haller, and Soemmerring, describe the spinal cord as terminating below by two small globular enlargements, of which the superior is oval, and the inferior conical. They have evidently mistaken an exception for the rule.

These three enlargements of the spinal cord constitute a totally different structure from that admitted by Gall, who, comparing with Haller the spinal cord of man and the vertebrata generally, to the double series of ganglia in annelida and insects, maintained that there are as many enlargements of the cord as there are pairs of nerves. A strict examination into facts is completely at variance with this opinion, for even in the fœtus, the temporary conditions of which so frequently resemble the permanent state of the lower animals, we find no trace of this series of enlargements. An erroneous inference, together with the aspect of the cord when surrounded by its nerves, have misled this celebrated physiologist, who should have sought for the representatives of the ganglia of insects, not in the spinal cord itself, but in the series of ganglia on the spinal nerves.†

* The spinal cord is capable of elongation and retraction; it is elongated during flexion, and returns to its original condition during extension of the vertebral column; the difference between the two states appears to me to be from an inch to fifteen lines.

In the body of an infant at the full time, which was affected with spina bifida in the sacral region, and died a short time after birth, the spinal marrow descended as low as the sacrum, and there was no cauda equina. Malacarne had already observed a similar fact; this peculiarity depends not upon an arrest of development in the cord, but upon adhesions contracted by it at an early period of fœtal life. (See *Anat. Pathol.* liv. xvii. art. SPINA BIFIDA.)

† These supposed enlargements are not to be found even in the spinal cord of the calf, which Gall took as offering the type of this structure. The committee of the institute likewise failed to discover them in the dog, the pig, the deer, the roe-buck, the ox, and the horse, in which Gall asserted that he had found them. The beautiful researches of Tiedemann into the de-

The existence of the three enlargements of the spinal cord above described, is in accordance with two general laws relating to the nervous system, viz. 1. that the size of the spinal cord is in proportion to the size and number of the nerves, which arise from and terminate in it, and to the functional activity of the organs to which those nerves are distributed; and 2. that the exercise of sensibility is connected with larger nerves than that of muscular contractility.

Now, the most numerous, and the most important nervous communications take place opposite those three enlargements. The nerves of the lower extremities correspond with the inferior or lumbar enlargements; those of the upper extremities, with the middle one; and the nerves of respiration, the nerves of the tongue, and a part, or perhaps the whole, of the nerves of the face, with the superior enlargement.

The cervical enlargement, which corresponds to the upper extremities, is certainly larger than the lumbar one, but this is because the upper extremities possess a greater degree of muscular activity than the lower, and also because they are the organs of touch.

This explanation is completely justified by comparative anatomy; and is applicable also to the differences in the length of the spinal cord: thus it is found that in the different species of animals, the length of the spinal cord depends, not upon that of the vertebral canal, nor upon the presence or absence of a tail, but is proportionate to the muscular energy, and to the degree of sensibility. Desmoulins, a young anatomist, too soon lost to science, has established this fact by incontrovertible evidence.*

The Form, Direction, and Relations of the Spinal Cord.

The spinal cord has the form of a cylinder flattened in front and behind (D, *fig.* 269.).

It exactly corresponds in *direction* with the vertebral column, every deviation of which it closely follows; and it is an interesting fact, that it escapes compression, even in angular curvatures of the spine.

The right and left halves of the spinal cord are perfectly symmetrical. There is less symmetry between the anterior and posterior halves, and still less between the upper and lower halves of the cord.

The spinal cord is divided by anatomists into a *body* and *extremities*. The body of the cord requires to be examined, both when covered by its proper sheath, and after the removal of that membrane.

The Body of the Spinal Cord enveloped in its proper Membrane.

The surface of the cord everywhere presents certain transverse folds, united by others running obliquely, so as to form zigzag folds, which were compared by Huber to the rings of a silkworm, and regarded by Monro as so many

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velopment of the spinal cord have completely overthrown Gall's opinion, which rested merely upon unsubstantiated analogies.

[It may be remarked, that though Gall's anatomical statement is not correct, his view as to the analogy is more in accordance with received doctrines than that of the author.]

* The spinal cord of birds furnishes a striking proof of the law which presides over the development of this part of the nervous system. There are no movements performed by animals which require greater force and agility than those observed in the act of flying. It is therefore not astonishing to find that the spinal cord is enlarged opposite the nerves which go to the muscles of the wings. It would be supposed that the portion of the cord which corresponds to the lower extremities should be much smaller than that corresponding to the upper, but yet the inferior enlargement is equal to the one for the wings, because, according to a more ingenious than probable idea, the lower extremities are the organs of touch in birds.

The spinal cord of the tortoise most clearly confirms the law which we have adopted from Desmoulins. The sort of calcareous and horny case in which the trunk of that animal is inclosed, is destitute of all power of motion or sensation; and it is found, the enlarged part of the spinal cord which corresponds to the upper extremities, is united to that which corresponds to the lower by an extremely slender portion.

small articulations; these folds are situated in the sheath of the cord, and are precisely analogous to those which have been noticed in the tendons during relaxation of the muscles, and those which we shall hereafter have to describe as appearing in relaxed nerves; they are effaced by extension of the spinal cord, and are reproduced when it resumes its original length.

The existence of these folds prevents that stretching of the cord which would otherwise occur in the different movements of the vertebral column. They endow the cord with a certain degree of elasticity.

The spinal marrow presents for consideration an anterior, posterior, and two lateral surfaces.

The *anterior surface* presents in the median line a *fibrous band*, which runs along the entire length of the medulla, and conceals the anterior median groove.

The *posterior surface* at first sight presents no trace of a median groove. Many anatomists, therefore, and especially Huber, have denied its existence; but with a little care we may detect a very delicate line which indicates the situation of the posterior median groove, to which we shall presently advert. On each side of the median line, both on the anterior and posterior surfaces of the cord, are seen the roots of the spinal nerves, (1 to 31, *fig.* 268.) which are arranged in four regular lines down the cord, and are divided on either side into the *anterior* (*a*, *fig.* 267.), and the *posterior* (*b*) roots. The differences, which we shall hereafter describe, as existing between these two sets of roots, both in their number, size, and mode of attachment, enable us, at first sight, to distinguish between the anterior and posterior surfaces of the cord.

If these roots be detached, it will be seen that their place of insertion is marked by a series of depressed points, which together constitute two furrows both upon the front and back of the cord, accurately described by Chaussier, under the name of the *collateral furrows* of the spinal cord. We cannot deny the existence of the posterior collateral furrows, but I do not think that the anterior collateral furrows should be admitted.

The *sides* of the spinal cord are rounded, and narrower than either the anterior or the posterior surface: there is no furrow upon these sides, as described by some authors. The two ligamenta denticulata are attached to them.

We must next examine the proper membrane of the cord, or the *rachidian pia mater*, which we shall name the *neurilemma* of the cord, from its analogy to the neurilemma of the nerves; we shall then describe the cord itself.

Neurilemma of the Spinal Cord, or Rachidian Pia Mater.

Dissection. It is difficult to separate the rachidian pia mater from the cord, in the greater number of subjects, on account of the softness of the cord itself and of the rapid changes which it undergoes after death. In order to succeed in doing so it is advisable to select the body of a person, who has died from an acute disease or from an accident. The spinal cord of new-born infants is more fitted for this purpose than that of adults, not only from its relatively greater density at that period of life, but also from its adhesion to the neurilemma being less firm.

In the bodies of infants, after making a circular incision through the neurilemma opposite the medulla oblongata, the sheath may be drawn downwards, in the same manner as an eel is skinned, or a stocking drawn off by turning it inside out. When the sheath is more adherent to the cord, it must be very carefully divided along each side of the median furrows, and then detached by breaking down, with the handle of a scalpel, the cellular and vascular prolongations which connect it with the cord.

Although the proper covering of the brain, or *cerebral pia mater*, consists essentially of an interlacement of vessels, the proper sheath of the spinal cord, or *rachidian pia mater*, is a fibrous, and therefore a strong membrane, which

supports and protects that part of the cerebro-spinal axis, as the neurilemma does the nerves.

The external surface of this membrane is surrounded with a net-work of remarkably tortuous bloodvessels; and vessels are also found in its substance. The spinal cord is visible through this semi-transparent membrane, which is naturally of a pearly white colour, but is sometimes dull, yellowish, blackish, or even covered with black spots, especially in the cervical region.*

This surface of the rachidian neurilemma is also rough, being covered with small cellular and fibrous filaments which float under water, and are the remains of small fibrous cords, which extended from the neurilemma to the arachnoid.

The *internal surface* of the neurilemma adheres to the spinal cord by a great number of cellular and vascular prolongations, which form areolæ or meshes in its interior, and which have been well described and figured by Keuffel.

Along the anterior median furrow, the neurilemma sends off a prolongation, which, entering that furrow, lines one of its walls, and is then reflected at its bottom, so as to line the other wall; within the substance of the duplicature thus formed the bloodvessels penetrate. A simple prolongation of the neurilemma of extreme tensity also enters into the posterior median furrows, and forms a line of separation between the two posterior halves of the spinal cord.

The neurilemma is prolonged below the lower extremity of the spinal cord as a fibrous filament, very well described by Huber, which is inserted into the base of the coccyx.

This filament the older anatomists regarded as a nerve, and named it the *nervus impar;* it is very strong considering its thinness; it is always tense, and appears to be intended to fix the lower end of the spinal cord; in this respect serving a similar purpose with the ligamentum denticulatum. Its upper part is hollow, and is filled with a grey and extremely soft substance.

The ligamentum denticulatum, which has been considered as a prolongation of the proper membrane of the cord, is attached to the external surface of this membrane; and the proper neurilemma of each nervous filament is also given off from this surface.

Monro has stated that a soft layer of grey substance covers the white substance of the spinal cord, and separates it from its neurilemma, but such a layer does not exist.†

While the other membranes of the spinal cord are much larger than the part which they have to invest, the neurilemma of the cord is exactly moulded upon it, and even exerts a certain degree of pressure upon it, as is evident from the manner in which the substance of the cord protrudes, when this covering is punctured; this compression occasions the apparent consistence of the cord, when it is enveloped in its sheath, a condition which contrasts so strongly with its softness when that sheath has been removed.

This compression, as well as the absolute inextensibility of the neurilemma, accounts for the rarity of effusions in the cord, and also for the fatal effects of even the slightest effusions within its substance when they do occur.

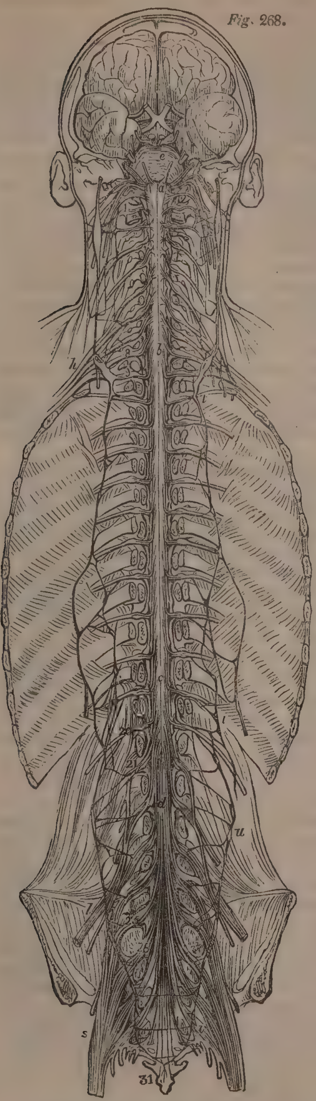
Structure. The proper membrane of the cord is essentially fibrous; nor has it any claim to be termed a vascular membrane (*tunica vasculosa,* Soemmerring). Its component fibres interlace in every direction, but the majority of them are longitudinal. It is quite evident that the vessels which ramify upon its surface, and afterwards penetrate it, do not belong to the membrane itself.

Uses. The neurilemma is essentially a protecting structure; it constitutes the framework of the spinal cord, and serves at the same time as a support for the

* These different shades of colour are much more common in certain animals, in the sheep for example, than in man; they result from the deposition of a colouring matter, and are in no way connected with any recent or previous morbid action.

† In several subjects, I have most distinctly seen a very thin yellowish layer, over the medulla oblongata, which dipped between the pyramidal bodies, and filled up the shallow groove which separates the olivary from the pyramidal bodies.

Fig. 268.



nutritious vessels of that organ; in this latter respect it has been compared to the pia mater of the brain. The transition from the spinal into the cerebral portion of the pia mater takes place gradually. The fibrous character of this tunic diminishes upon the medulla oblongata, and tuber annulare, and is entirely lost opposite the peduncles of the brain; whilst its vascular character, on the contrary, becomes gradually more and more marked as it passes from the cord towards the brain.

It has been stated, the neurilemma is the secreting organ of the spinal cord; one might as well say, that the testicle is secreted by the tunica albuginea, and the heart by the pericardium.

The Body of the Spinal Cord deprived of its Neurilemma.

When the neurilemma of the cord is removed, the spinal nerves are also taken away. We shall hereafter have to inquire, whether this fact should lead us to conclude, that the nerves do not enter into the substance of the cord, but merely come into contact with it.

We would observe, however, in this place, that the posterior roots of the spinal nerves arise in a perfectly regular line, whilst the anterior roots come off irregularly from different points of the corresponding medullary column.*

The anterior median groove, and *the commissure.* The *anterior median groove,* or fissure (*fig.* 268.; *f*, *fig.* 269. D), penetrates to about one-third of the thickness of the cord. At the bottom of the groove, which is occupied by a prolongation of the neurilemma and a great number of vessels, is seen an extremely thin white layer, perforated with foramina, which is named the *anterior commissure* (commissure longitudinale, *Chaussier*). The foramina in this structure are intended for the transmission of tufts of vessels, which enter the substance of the cord. The alternate arrangement of these foramina greatly increases the difficulty of drawing out the vessels, and gives to the commissure the appearance of being formed by interlacing fibres;

* This mode of origin of the anterior roots is perfectly distinct in the spinal cord of the fœtus or new-born infant; up to this period, the tract, from which the anterior roots arise, is still formed of grey substance. The roots, which are white, emerge from this grey tract, and when the neurilemma is removed, their small white ruptured ends which remain may be traced into the substance of the cord.

and, in fact several anatomists have not only admitted such an interlacement, but have expressly stated that it was produced by the spinal nerves themselves.*

According to Gall and Spurzheim, the bundles of which this commissure consists are directed transversely, and are fitted into each other like the molar teeth; but I repeat, that the most careful examination demonstrates nothing in the commissure, besides a white lamella, perforated for the transmission of bloodvessels.

The posterior median groove. The posterior median groove or fissure (*a*) not only exists, but is much deeper than the anterior one. Its narrowness, and the tenuity of the membranous prolongation which enters it, have alone concealed it from the observation of anatomists; there is no white band analogous to that of the anterior median fissure at the bottom of this fissure, but the grey substance of the commissure is all that is seen.

As there are two median furrows, it follows that there are really two distinct spinal cords, connected together by an extremely thin band or commissure.

The furrows opposite the posterior roots of the nerves, or the posterior lateral furrows. Immediately to the outer side of the line of origin of the posterior roots of the spinal nerves, there is a greyish line or furrow (*i*), which extends the whole length of the cord. If a stream of water be allowed to fall upon this line, the continuity of the cord is soon destroyed, and the water penetrates to the centre of the organ.

But there are no true fissures in these situations, analogous to the anterior and posterior median furrows. The separation is effected by the destruction of the grey substance, a prolongation of which reaches to the surface of the cord opposite these points. We shall, nevertheless, suppose these furrows to exist in accordance with the views of Soemmerring and Rolando, who divided each half of the spinal cord into two columns—a *posterior column*, consisting of that portion (*e*) which is comprised between the posterior median furrow (*a*) and the posterior roots (*i*), and an *antero-lateral* column, including all that portion (*d*) which is situated between the anterior median furrow (*f*) and the supposed posterior lateral furrow (*i*). We must also admit with Haller, Chaussier, Gall, and Rolando, a third column on each side; these may be called the *posterior median* columns, and are continuous with the projecting bundles which form the borders of the calamus scriptorius, and which are each limited externally by a slight groove. These small and exceedingly narrow columns, the existence of which is admitted by most anatomists in the cervical region only, are prolonged through the whole extent of the spinal cord.

Is there an *anterior lateral furrow?* If the line on the outer side of the attachment of the anterior roots of the spinal nerves be closely examined, the appearance of a furrow is seen along the whole of the cord. But if water be allowed to fall upon that line, it is found that there is no fissure or furrow properly so called, and that the jet of water has no more effect upon this line than on the adjoining parts; we are therefore led to reject, with Rolando, both these anterior lateral furrows and the *lateral* tracts described by Chaussier, which would be bounded in front by the furrow of the anterior roots, and behind by that of the posterior roots; these *lateral* tracts have, nevertheless, become celebrated, since so much importance has been attached to them by Sir C. Bell and Bellingeri as the *lateral columns* of the spinal cord.

From what has been stated above, it follows, that each half of the cord is composed of two columns, a posterior and an antero-lateral, and as an appendage to the posterior column, of a small column, which forms the border of the posterior median furrows.

* There is no physiological or pathological fact which demonstrates the crossing effect of lesions of the spinal cord.

Internal Structure of the Spinal Cord.

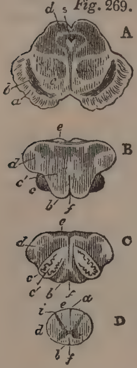
The following results regarding the structure of the cord have been obtained by various modes of investigation — by making sections of it; by acting upon it with a stream of water; by hardening it in alcohol and dissecting it; by studying its development; and lastly, by a reference to its comparative anatomy, which appears to be necessary to complete the knowledge acquired by the other means of investigation.

Sections of the Cord.

It appears from an examination of the external structure of the spinal cord, that it consists of two white juxtaposed cylinders; that the surfaces by which these cylinders correspond are flat, closely in contact, and united together by a median commissure; and that each of them may be divided into two columns, the one *posterior* and smaller, of which the posterior median column is only an appendage; the other, *antero-lateral*, which forms two thirds of the circumference of the cylinder.

Horizontal sections. If various horizontal sections be made through different parts of the spinal cord, we see that each half consists of a cylinder of white substance containing grey substance in its interior (see *fig.* 269. D); that the median commissure is composed of a white layer (*white commissure*) and a grey layer (*grey commissure*); and that in each section the grey matter has a tolerably close resemblance in form to the letter x, the two halves or curves of which are joined in the middle by a horizontal line, whilst the extremities of the curves are directed towards the origins of the anterior and posterior roots of the nerves. The posterior extremities reach much nearer to the surface than the anterior. We perceive also in these different sections, that the circumference of the cord is not perfectly regular, but is somewhat sinuous, as we shall presently mention.

Fig. 269.



The size of the central grey mass in each half of the spinal cord, the length and thickness of the prolongations or points, which it sends off towards the anterior and posterior roots, and lastly, the thickness of the grey commissure, present many varieties, according to the place of section *; and hence there is a discrepancy between different authors as to the appearances of this section. Thus Huber compared the section of the grey matter to an os hyoides, Monro to a cross, Keuffel to four rays converging towards a central point.

Rolando has given figures of sections of the cord at every part of its length.

From sections of the cord, the general fact is established, that the white substance incloses the grey matter. The thin layer of grey matter on the surface of the cord admitted by Monro, has been justly rejected by all anatomists. The relative situation of the two substances in the cord, which is the reverse of what is observed in the brain, has attracted the attention of anatomists, and various explanations of greater or less ingenuity, but all hypothetical, have been given of this fact.

According to Rolando, there are two kinds of grey matter in the cord, one occupying the anterior, and the other the posterior half of the cylinder; and these two halves are fitted into each other by a series of indentations, like the bones of the cranium.

* I would recommend five sections of the cord, which appear to me to give a very accurate notion of its internal structure — the first should be immediately below the decussation of the pyramids, the second through the middle of the brachial enlargement, the third through the dorsal constricted part, the fourth through the middle of the lumbar enlargement, and the fifth near the apex of the cone formed by the lumbar enlargement.

I have never been able to convince myself of the existence of these two kinds of grey matter, but I have distinctly observed the denticulated appearance of the circumference of the grey matter, which indicates that the grey and white matter mutually penetrate into each other.

The colour of the grey substance varies considerably. In some subjects it is whitish, and can only be distinguished from the white matter by its softness, its vascularity, and its not having a fibrous structure. The younger the individual, the more marked is the difference in colour between the two substances.

The two substances appear also to differ in their relative proportions in different individuals. Keuffel has ascertained that the grey matter is more abundant in man than in the lower animals; and this fact would account for the pre-eminent sensibility of the human subject, in accordance with the view of Bellingeri, who considers that the grey matter is the seat of sensation.

These horizontal sections enable us not only to determine the relative position and proportions of the white and grey substances, but also to distinguish the superficial furrows from those which really enter into the cord; the existence of these columns in the spinal cord, which have already been described, is in this way fully established.

Vertical sections. The most important of these is one made from before backwards in the median line, as to separate the two halves of the cord. Each of these halves may then be unfolded like a ribbon, on the inner surface of which the grey matter forms a thin layer.

A transverse vertical section, through the centre of the cord, displays the mode of origin of the anterior and posterior roots of the nerves.

Examination of the Spinal Cord under a Stream of Water.

The different sections above mentioned expose the general internal arrangements of the cord, rather than its actual structure.

Until lately, authors had regarded the spinal cord as consisting of a semifluid pulp, which oozed out when the neurilemma was divided. Several had said, incidentally, and without distinguishing between the white and the grey substance, that the cord had a fibrous structure, and that its fibres were directed longitudinally. Gall supposed the cord to consist of a series of ganglia arranged one upon the other; but it is now generally admitted that the white matter is fibrous, and that its fibres have a linear arrangement; and this is clearly shown by examining this organ by means of a stream of water, the force and size of which may be varied at will.

When directed upon the surface of a vertical section, made from before backwards down the middle line, the stream of water penetrates the substance of the cord through the grey commissure, breaks down the central grey matter, and spreads the cord out like a ribbon, from which it is very difficult to wash off all the grey matter. When treated in this way, each half of the cord is almost immediately subdivided into two columns, and if the stream of water be now directed upon the internal surface of the columns themselves, they may be separated into a great number of wedge-shaped vertical lamellæ, directed from the circumference to the centre, the thick external backs of which are turned towards the surface, and the thin internal edges towards the centre of the cord. Now, as all these lamellæ are not of equal depth from back to edge, their internal edges reach to different distances from the centre; hence the denticulated appearance of the circumference of the grey matter in a section; and hence, also, the mistake of Rolando, in describing the white matter as formed by a medullary layer folded a very great many times upon itself.*

* Rolando has even counted these folds; he numbers fifty in the spinal cord of the ox, opposite the origin of the sixth pair of sacral nerves; and about thirty opposite the third pair of

According to my observations, each lamella is completely independent of the adjacent ones, and pathological anatomy fully confirms this observation, by showing that one only may be altered or atrophied, whilst the others remain unaffected.

If the action of the stream of water be continued, these medullary lamellæ are decomposed into very delicate juxtaposed filaments, which extend along the entire length of the cord; they are all independent of each other, and are merely connected by cellular tissue and some vessels.

The structure of the spinal cord is therefore filamentous or fasciculated; its filaments are almost perfectly identical with those which constitute the proper substance of the nerves. Each filament in the cord traverses its entire length, as each nervous filament extends along the whole nerve.

The very important inference to be drawn from these facts is the independence, not only of each lamella, but, I may venture to say, of each filament. *

Examination of the Spinal Cord hardened in Alcohol.

When deprived of its humidity by alcohol, the spinal marrow becomes very firm, extensible, and elastic. Its filamentous texture becomes very apparent, and the filaments themselves, which from the contraction of the cord are flexuous, may be separated from each other, either by the handle of the scalpel, or by slight traction. I have not seen that interlacement of the fibres of the cord, which is figured in the beautiful plates of Herbert Mayo, and which in my opinion is only apparent, and is produced by drawing the parts under examination in different directions.

The Cavities or Ventricles of the Spinal Cord.

Several anatomists are of opinion, that there is a canal in each half of the spinal cord. †

Morgagni has slightly alluded to its existence, which he had not leisure to trace for a greater extent than about five fingers' breadth. ‡

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sacral nerves; both of these observations refer to the anterior columns only, for in the two figures which he gives of them, the posterior columns appear to have no folds. Rolando made his observations upon spinal cords which had been macerated either in pure water, or in salt and water.

* [The microscopic structure of the white and grey substances of the brain and spinal cord has been investigated by Fontana, Ehrenberg, Weber, Remak, Valentin, and others. The fibres of the white matter consist of coherent threads of a soft semi-transparent tenacious substance, inclosed in an extremely delicate homogeneous or stuctureless sheath, which is very difficult of detection: these fibres are smaller than those of the nerves; they differ much in size, but each of them is of uniform diameter throughout; when submitted to the slightest pressure during examination, they have a remarkable tendency to become varicose or beaded, a property which is peculiar to them and to the fibres of the olfactory, optic, and auditory nerves, which also resemble the fibres of the brain in other respects.

The grey matter of the brain and spinal cord consists of large reddish grey globules, containing a nucleus and one or more nucleoli, and having spots of pigment upon them, in situations where the grey matter is darker than usual. Surrounding and attached to these globules there are minute jointed fibres, which are marked at intervals with granules (nuclei); by Ehrenberg these jointed fibres were considered to be of the same nature as the fibres of the white matter, differing from them only in size; by Müller and Schwann they are regarded as organic nervous fibres, resembling those found in such abundance in the sympathetic nerves and ganglia; whilst by Valentin and others they are supposed, not only in the brain but also in the ganglia and nerves, to be the filaments of a delicate cellular tissue.

The mode in which the white fibres of the brain and spinal cord end in the grey substance is not well made out; according to Valentin they separate to admit the grey globules between them, and then unite with one another so as to form loops.

The substance of the brain and spinal cord, according to Vauquelin, contains 80 per cent. of water; its solid constituents consist of albumen, stearine and elaine, phosphorus (1·5 per cent.), osmazome, some acids and salts, and sulphur.]

† It is unnecessary to say, that the existence of the single central canal admitted by some authors, is quite irreconcilable with the real structure of the cord.

‡ *Adversaria Anat.* vol. i. p. 17. Morgagni relates, that having separated the medulla oblongata from the rest of the spinal cord by a horizontal section, he saw in the substance of the cord, and for the space of about five fingers' breadth (*et fortasse etiam longius si quis tunc otium habuisset ulteriorem medullam e vertebris eximendi*), a cavity which admitted the end of the fin-

Gall relates, that in examining the body of an infant affected with spina bifida, he cut transversely through the cord, and found that it contained two canals, which he traced into the substance of the medulla oblongata and tuber annulare, beneath the tubercula quadrigemina, and as far as the optic thalami, where they terminated in a pouch as large as an almond.*

It is certain that, up to the fourth month of fœtal life, each half of the spinal cord contains a canal precisely similar to that which exists in fishes; but after this time the grey matter takes the place of the gelatiniform fluid which had occupied the canal. However, in one case I found the canal persisting after birth.

The Medulla Oblongata.

Situation. The *medulla oblongata*, the *rachidian* bulb, or *cranial enlargement*, is that conoid enlargement (*a, fig.* 268.) which forms the upper part of the spinal cord, crowning it like the capital of a column: it is situated upon the basilar groove of the occipital bone, and connects the spinal cord with the cerebrum and cerebellum. It was named *medulla oblongata* by Haller; but it has also been called the *cauda* or *tail* of the medulla oblongata, this term being derived from a comparison of the pons Varolii, the four peduncles, and the medulla oblongata to an animal, the body of which was represented by the tuber, the arms by the anterior peduncles, the legs by the posterior peduncles, and the tail by the rachidian bulb.

External Conformation of the Medulla Oblongata.

The medulla oblongata is received into the deep groove on the fore part of the circumference of the cerebellum (see *fig.* 276.), so that its anterior part only is exposed.

In man and the mammalia the medulla oblongata is *bounded* above and in front by the tuber annulare or pons Varolii (*a, fig.* 270.); but above and behind its limits are quite artificial, for it is prolonged upwards beyond the pons, as we shall presently see. Its limits below are altogether arbitrary: the medulla oblongata, in fact, does not contract abruptly, as the term, *neck of the bulb*, applied to its lower extremity, would seem to imply, but it is very gradually narrowed, so as to become continuous with the spinal cord.

A plane, which is a tangent of the lower surface of the condyles of the occipital bone, would correspond with the lower boundary of the medulla oblongata.† I think however that it is more rational to fix this boundary according to the precise point where the medulla undergoes some decided modifications; and this point is immediately below the decussation of the pyramids.

The medulla oblongata is from fourteen to fifteen lines in length, nine lines in breadth, and six in thickness; it is therefore much broader and thicker than the spinal cord.

The medulla oblongata is directed obliquely, like the inclined plane of the

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ger; every thing appeared to be in a natural state, excepting this cavity. He adds, that he had never met with so large a cavity; which seems to imply, that he had seen cavities of this kind before. — *Neque enim alias tantam aut quæ huic accederet vidi.*

* Spina bifida and hydrocephalus have no direct relation with the persistence of the canals of the spinal cord; and on this point, I can remove all the doubts expressed by Keuffel (*De Medullâ Spinali*, 62.) concerning Morgagni's observation. "Forsan nos quoque," says Keuffel, "eam (scilicet medullæ spinalis caveam) invenissemus, si medullam spinalem ex homine hydrocephalico aut spinâ bifidâ laborante, inquirere potuissemus. Utinam hujusmodi opportunitas, si occurreret, a nemine negligatur, ut tandem de hâc re certiores fiamus." In five infants affected with spina bifida, and two who died of chronic hydrocephalus, which I examined for this purpose, the spinal marrow was perfectly normal. Tiedemann regards the canals described by Gall as produced by insufflation.

† I have made experiments upon several subjects, which show that the relations of the medulla oblongata to the foramen magnum vary according as the head is directly vertical, flexed, or extended; an instrument thrust horizontally between the atlas and occipital bone divides the medulla oblongata at different parts in these various positions of the head.

basilar groove, so that it forms with the spinal cord a very obtuse angle, which projects backwards.

In shape it resembles a cone flattened in front and behind, and having its base turned upwards and its apex downwards; it has, therefore, four surfaces, viz. an anterior, a posterior, and two lateral.

Anterior Surface of the Medulla Oblongata.

This surface (*fig.* 270.) is directed downwards, and is therefore named inferior by some anatomists; it is convex, and is lodged in the basilar groove of the occipital bone; it can be properly examined only after its neurilemma has been dissected off, which is easily done, because its substance is denser than the spinal cord.

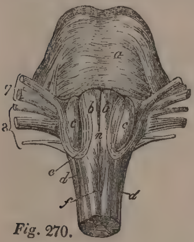

Fig. 270.

On this surface we observe a *median furrow* (*f*), into which numerous vessels enter: this furrow, which is not nearly so deep as the anterior median furrow of the spinal cord with which it is continuous, is interrupted by a decussation of fibres about ten lines below the pons Varolii (below *n*), and terminates above in a tolerably deep fossa (*le trou borgne*, or *foramen cæcum*, of Vicq d'Azyr), at the point where the furrow meets the pons. Not unfrequently some transverse fibres occupy the place of this median furrow, in which case the anterior surface of the medulla oblongata resembles the pons Varolii; sometimes these transverse fibres are found upon only a part of the medulla oblongata.

On each side of this median furrow are seen two eminences, which seem as if moulded in relief upon the part, and which form two planes succeeding one another like steps from within outwards. The two internal eminences are called the *anterior pyramids*; the two external are named, from their shape, the *olivary bodies.*

The Anterior Pyramids.

The *anterior pyramids* (*Vieussens*; *b b*), situated on each side of the median line, and to the inner side of the olivary bodies, are two white pyramidal bundles (bandes médullaires, *Malacarne*), which extend through the entire length of the medulla oblongata; they project in relief upon the body of the medulla, and seem to emerge or originate near its narrow portion or neck, where they separate from each other the anterior columns of the spinal cord, from which columns they are quite distinct: at their point of emergence they are closely approximated and narrow, being about a line and a half in width; they pass somewhat obliquely upwards and outwards, become more prominent, and about three lines wide; having reached the pons Varolii, they become rounded and cylindrical, and are constricted before they enter the substance of the pons, in which we shall afterwards trace them.

When the two pyramids are gently held apart, it is said that some transverse fibres are seen passing from one to the other, along the bottom of the median furrow; and it is even stated that there is a decussation of their fibres: this, however, is only apparent, and I cannot here too particularly caution the student against those illusive appearances, which depend either upon the existence of foramina for the passage of vessels, or may be produced by pulling about the scattered fibres in drawing the parts asunder. It will soon be shown that there are no transverse fibres here, and that there is no decussation of fibres at an acute angle along the whole length of the anterior pyramids, as was admitted by Petit, Winslow, Santorini, and others.

The two halves of the medulla oblongata are in fact merely applied to each other, and agglutinated together. There is no decussation excepting at the point where the pyramids emerge.

The Olivary Bodies.

Upon the anterior surface of the medulla oblongata, to the outer side of the anterior pyramids, and upon a plane somewhat posterior to them, are found two white ovoid bodies (corpora ovata), sometimes projecting in relief: these are peculiar to the human subject, and are more prominent in the fœtus and new-born infant than in the adult. They were first described by Eustachius, and afterwards more accurately by Vieussens, who on account of their shape gave them the name of *olivary bodies* (*corpora olivaria*, *c c*); they are much shorter than the anterior pyramids, being not more than six lines in length; they are directed obliquely downwards and inwards. The upper extremity of the olivary body does not reach the pons Varolii, but is separated from it by a deep furrow; the lower extremity, which is less prominent than the upper, is bound down by a bundle of arched fibres, the concave borders of which are directed upwards (*processus arciformes*, *e*). The outer border of the anterior pyramids and the series of nervous filaments which unite to form the hypoglossal nerve (9, *fig.* 276.) constitute the internal boundary of each olivary body; and a deep furrow, directed vertically, separates them on the outer side from the inferior peduncles of the cerebellum or the restiform bodies.*

It is of importance to observe, that that portion of the olivary body which projects on the outer side of the pyramid is only the external half of the olivary body, its internal half being imbedded in the substance of the medulla oblongata, so as to reach behind the anterior pyramid.†

The Posterior Surface of the Medulla Oblongata.

This surface is partly concealed by the cerebellum, being received into a groove on its under surface, and cannot be completely exposed unless the medulla oblongata be forcibly bent forwards, or the middle part of the cerebellum be divided vertically. It is then seen that the cord appears to open out (*t*, *fig.* 271.) opposite the upper part of this surface, and to be turned inside out, so that the grey substance is exposed. In consequence of this separation of the posterior columns of the cord, there is left between them a shallow, triangular, or V-shaped depression (*p*), the bottom of which is smooth, and forms the anterior wall of the fourth ventricle; Herophilus named this depression, from its appearance, the *calamus scriptorius.*

Fig. 271.

A vertical median groove corresponds to the shaft of the quill; whilst its barbs are represented by certain white medullary lines, which vary exceedingly in number, and are not symmetrical; some of these lines are lost upon the walls of the ventricle, and others turn round the lateral surface of the medulla oblongata, and constitute in part the origin of the auditory nerves. The point of the pen is represented by the very acute inferior angle formed by the sides of the depression, which terminates below in a cul-de-sac, the *fossette of the*

* I do not say, with some authors, that the filaments of origin of the glosso-pharyngeal and pneumogastric nerves (8, *fig.* 270.) bound the olivary bodies behind, for these filaments arise from the inferior peduncles of the cerebellum, or the restiform bodies, not from the furrow between those peduncles and the olivary bodies.

† In the body of a female who died at the Maternité, the left pyramidal and olivary bodies were not more than half their usual width. It might have been supposed that they were atrophied; but the patient had exhibited no symptom indicative of so serious and uncommon a lesion. With a little attention, I could easily see that the pyramid was divided into two portions, the anterior of which occupied the usual position, whilst the posterior covered the posterior half of the olivary body.

fourth ventricle, also called the *ventricle of Arantius.* According to some authors, at the point of the calamus is situated the upper orifice of a canal, which runs through the whole length of the spinal cord; such a canal however does not exist, but is in fact produced by the means employed to demonstrate it, for example, by insufflation, by the introduction of a probe, or by the weight of a column of mercury. A slight V-shaped deposit of corneous matter is constantly found inserted within the correspondingly shaped bifurcation of the columns of the cord: between the branches of the V is found the prolongation of grey substance, which is continuous with the grey matter of the cord.

The medullary columns which immediately bound the calamus on each side, and which result from the separation of the elements of the cord, are formed by the posterior median columns (*e, fig.* 269. B C, and *fig.* 271.), already described, which become slightly enlarged where they separate from each other, so as to form a mammillary projection, and then terminate insensibly upon the back of the restiform bodies: we shall call the upper part of these columns the *mammillary enlargements of the posterior median columns*, and not "*posterior pyramids.*"*

On the outer side of these mammillary enlargements are found the *restiform bodies* (*d, fig.* 269. C; *fig.* 271.), which, as we shall afterwards describe, pass to the cerebellum, and may be said to form its root; they are also called the *inferior peduncles of the cerebellum*, or *processus à cerebello ad medullam oblongatam.* Ridley named them the *restiform bodies*, or cord-like processes; and others again call them the *posterior pyramids.*

The Lateral Surface of the Medulla Oblongata.

Fig. 272.

These present (*fig.* 272.), in front, the olivary bodies (*c*), which we have already seen upon the anterior surface. Behind them are the restiform bodies (*d*); and lastly, about three lines below the lower extremity of each olivary body, is found an oblong projection, the colour of which is intermediate between that of the white and that of the grey substance: this projection is continuous with the grey matter of the furrow, from which the posterior roots of the spinal nerves arise; and Rolando, who first directed attention to it, has named it the *ash-coloured tubercule* (tuberculo cinereo).

The arched fibres, or *processus arciformes* (*e, fig.* 270.), pointed out by Santorini, and still better described by Rolando, are principally found upon the lateral surfaces of the medulla oblongata; they consist of filaments of medullary substance, which vary exceedingly in number and arrangement; they appear to arise from the anterior median furrow of the medulla oblongata, to turn like a girdle around the pyramidal and olivary bodies, and having reached the restiform bodies, to pass obliquely upwards and outwards to terminate upon the sides of the restiform bodies. These arched fibres sometimes seem to be entirely wanting; at other times they are collected on each side into two bundles; one superior, which turns round the anterior pyramid, as that body is about to enter the pons; the other inferior, which covers and circumscribes the lower extremity of the olivary body. Lastly, the pyramidal and olivary bodies are not unfrequently found to be completely and regularly covered by a thin layer of circular fibres: it will be presently shown, that these fibres dip into the anterior median furrow of the medulla oblongata, and reach as far as the posterior median furrow.†

* [The term posterior pyramids is nevertheless applied to these bodies by many modern anatomists.]

† Ought we to regard as a part of this system of arched fibres, a small slender cord which

Internal Structure of the Medulla Oblongata.

The internal structure of the medulla oblongata should be examined by means of sections; by the ordinary method of dissection; by separating its elements by means of a jet of water; and by dissecting it, after it has been hardened in alcôhol, or boiled in oil.

Sections.

Horizontal sections. Following the example of Rolando, we shall examine four sections of the medulla oblongata.

The first should be made immediately below the decussation of the pyramids; the second, opposite the middle of the decussation; the third, through the middle of the olivary bodies; and the fourth, immediately below the pons.

The *first section* presents exactly the same appearances as a section of the spinal cord.

The *second* presents a very different arrangement: the decussating bundles of the pyramids are of very considerable size, and occupy the anterior two thirds of the substance of the medulla: their section represents a triangle having its base turned forwards, and its truncated apex backwards. The grey matter is not circumscribed, as in the first section, but appears to penetrate irregularly into the white substance of which the remaining part of the medulla consists. The white substance itself has not the pure whiteness of medullary substance; nor does the grey matter resemble that of the rest of the spinal cord, but it is of a *yellowish grey* colour, and is much denser.

The *third section* through the middle of the olivary bodies (*fig.* 269. C) presents, besides the triangular section of the pyramidal bodies (*b*), the serrated section of the *corpus dentatum* (*c*′) of the olivary bodies (*c*); it enables us to form an accurate idea of the shape and size of these bodies, which extend to each side of the median line; it shows that they are directed obliquely inwards and backwards, and that they consist of successive layers, viz. of an external white layer, of an interrupted yellowish layer, and of a second white layer, which lines the inner surface of the yellowish one. It is seen, that the corpora dentata of the olivary bodies are interrupted, or rather open on the inner side towards the median line, so as to admit the white fibres with which their interior is filled. The waving grey line seen on these sections depends upon the yellow layer being frequently folded inwards and outwards upon itself; and from this appearance the terms *corpus dentatum*, or *corps festonné*, have been applied to the grey substance of the olivary bodies. The remaining part (*d*) of the medulla oblongata consists of a substance which is of the colour of coffee mixed with milk, and which offers more resistance to the knife than other parts of the medulla, and consists neither wholly of white matter nor wholly of grey, but of a mixture of both.

The *fourth section*, made immediately below the pons (*fig.* 269. B), presents a triangular surface on which we remark, at each of the posterior angles, a thick white bundle, almost as large as the posterior pyramidal body, and which will be hereafter shown to constitute one of the roots of the fifth nerve: these bundles are also seen upon the third section made through the olivary bodies, but they are much smaller than in this section. The section of the two anterior pyramids (*b*) is circular at this point. The centre of this section of the medulla consists entirely of a greyish white, or coffee coloured substance (*d c*′), covered by a white layer. The greyish white substance belongs specially to the medulla oblongata; the surrounding white layer is the continuation of the columns of the spinal cord.*

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surrounds the upper part of the anterior pyramids, and which in other respects has a similar arrangement to the arched fibres generally?

* The medulla oblongata of a child, seven or eight years old, is much better adapted for the examination of these sections, than that of an adult or old subject, because the two substances

The oblique sections display appearances corresponding with those of the horizontal section.

Vertical section. A very interesting section of the medulla oblongata is a vertical one, extending from before backwards through the median line. I prefer the plan of forcibly separating the two halves of the medulla to that of dividing it with a scalpel. By this means it may be shown, that there are in the median line of the medulla some antero-posterior fibres, which appear to me to vary in number in different subjects: these fibres (*o*, *fig.* 274.) run from behind forwards, through the whole antero-posterior diameter of the medulla; having reached the anterior median furrow, they pass horizontally outwards to cover the pyramids and olivary bodies, and form the arched fibres already described. These antero-posterior fibres are limited below by the decussating fibres of the pyramids.

Examination of the Medulla Oblongata by Dissection under a Jet of Water, and when hardened in Alcohol.

The *anterior pyramids* may be separated by ordinary dissection, and a tolerably accurate view obtained of their decussations; and, moreover, the medulla oblongata may be divided into two lateral halves, and its principal parts may then be isolated. The examination of the medulla when hardened in alcohol, or boiled in oil or in a solution of salt, leads to important results by enabling us to dissect it fibre by fibre, and to trace these fibres above and below their points of decussation. Together with these different modes of investigation, I have employed another, viz. that of acting upon the medulla and its parts by a jet of water, the force and size of which is to be varied at pleasure, and the drops of which insinuate themselves between the fibres, and separate them from each other*.

If a stream of water be directed upon the anterior pyramids, the fasciculated arrangement of their component fibres, all of which are parallel, will be clearly demonstrated; and it will also be seen that these two bodies are not mere medullary bands, but are two three-sided bundles occupying an angular groove between and in front of the two olivary bodies (*fig.* 269. C).

The *decussation of the anterior pyramids* demands attention, as one of the most important points in the anatomy of the cerebro-spinal axis.

On examining the anterior median groove of the medulla oblongata (see *figs.* 270. 276.) it will be found that, at a distance from the pons Varolii of about ten lines (Gall says an inch and some lines), the anterior pyramids divide into three or four bundles, which alternately interlace in a regular manner (below *n*), so as to form a plaited structure of from two to four lines in length. Is this decussation only apparent? and if so, does the appearance result, as has been said, from the traction of parallel fibres in opposite directions? or do the pyramids commence by alternate bundles arising from each side of the middle line, and does this alternate arrangement occasion the appearance of a decussation? or, lastly, do the right and left pyramids actually cross like the limbs of the letter X?

On consulting the various authorities on this subject it is found, that the decussation of the pyramids, first pointed out by Aretæus, re-noticed by Fabricius Hildanus, and demonstrated by Mistichelli † and Pourfour Dupetit ‡, has been admitted by Santorini, Winslow, Lieutaud, Duverney, Scarpa, and Soemmerring; and that the opposite opinion has been maintained by Mor-

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are blended in the latter; a stream of water, directed upon the sections, will greatly assist the examination by making the colours more distinct.

* If we employ a stream of water in the examination of a fresh medulla oblongata, it may easily be conceived that the results will be much more conclusive than if we had thus examined one which had already been subjected to different modes of preparation that may have altered its structure.

† Trattato dell 'Apoplessia, 1709.

‡ Lettres d'un Médécin des Hôpitaux, 1710.

gagni, Haller, Vic d'Azyr, Sabatier, Boyer, Cuvier, Chaussier, and Rolando.* As to Gall and Spurzheim, they do not seem to have had a decided opinion upon this point; for, after having appeared to admit the decussation in some passages of their work, they say elsewhere that the small cords of the pyramids do not form a true decussation, but merely intersect and pass over each other obliquely.

In order to settle the question of decussation, I submitted the medulla oblongata to the action of a jet of water upon both its anterior and posterior surfaces; and by then examining it from behind forwards I was able to ascertain that the right and left pyramidal bundles do most evidently decussate (*a*, *fig.* 273.); that this decussation is effected, not only from side to side, but also from before backwards (*b*, *fig.* 274.); that the left pyramidal bundle (*b*) passes downwards to the right side and backwards (*w*), traverses the grey matter of the cord, and becomes continuous with the right lateral column of the cord, and *vice versâ;* and, lastly, that the anterior pyramids are not in the slightest degree continuous with the anterior columns of the spinal cord.

The olivary bodies. When the anterior pyramids are removed, it is seen that the olivary bodies (*d*, *figs.* 273, 274.) do not consist merely of the prominent masses which project beyond and on the outer side of the anterior pyramids, but that they extend inwards to the median line behind the pyramids, which are received in a slight concavity formed by the anterior surfaces of the olivary bodies (*fig.* 269.C). This arrangement is very evident without any preparation in anencephalous infants, or in such as are born with very imperfectly developed brains: the situation of the atrophied pyramids is then occupied by two tracts of grey matter, and the olivary bodies, more developed than usual, reach as far as the median line.

When a jet of water is directed against the median line between the olivary bodies, it encounters a white and very dense tissue, upon which it produces little effect.†

As soon as this tissue has been removed with the knife, the water insinuates itself into the substance of the olivary bodies, which, as we have seen, are open towards the inner side; each olivary body is then spread out, its anterior half is turned outwards, and assumes the appearance of a dense yellowish layer folded upon itself, like a leaf whilst within its bud; after some white lamellæ are removed by the action of the water, the posterior half is exposed, and displays a similar appearance to that of the anterior half. Rolando compares the arrangement of this yellow folded layer, or corpus dentatum of the olivary body, to a flattened purse (*borsa appiattita*), the neck of which is open, somewhat constricted, and directed backwards and towards the median line.

Gall and Spurzheim regarded the olivary bodies as ganglia, but these anatomists appear to me to have singularly misapplied the term ganglion, which they have given to such dissimilar parts as the olivary bodies, the corpora striata, and the tuber annulare.

Lastly, by directing the stream of water against the median line, and by assisting its action by gently drawing the parts asunder, the medulla oblongata becomes divided into two perfectly similar halves, excepting opposite the decussation. A beautiful preparation may thus be made exhibiting the separa-

* Of all who have denied the reality of the decussation, Rolando appears to me to have opposed the doctrine with the greatest force. He examined the subject with the greatest attention; he made horizontal sections of the medulla oblongata, but he could never see any thing more than the alternate origin of the fasciculi which constitute the anterior pyramids; he could never find that the bundles of the right side passed over to the left, and *vice versâ*. In reply to the objection, that without admitting the decussation it is impossible to account for the cross effects of injuries or diseases of the brain, he states that these are explained by the intimate union between the optic thalami and tubercula quadrigemina of the two sides, and between the two halves of the pons Varolii and medulla oblongata. The error of Rolando evidently arose from his attaching such exclusive importance to sections, as a means of determining the structure of the medulla oblongata.

† I have frequently been led to regard the white medullary substance which is situated between the olivary bodies, and passes into each of them, as a transverse commissure, which might be called the commissure of the olivary bodies.

tion of the two halves of the medulla oblongata and spinal cord, and leaving the decussation of the anterior pyramids.

It appears then, on the one hand, that the anterior pyramids are not formed by the anterior columns of the spinal cord, and, on the other hand, that the posterior columns of the cord become separated from each other behind when they have reached the medulla oblongata. What then becomes of the white bundles of the cord in the medulla oblongata?

Having arrived opposite the neck of the bulb, the white matter of the cord is divided into two bundles, one *anterior*, which forms the *anterior pyramid* (*b*, *fig.* 273.), and may be called the cerebral bundle, because it passes up (*b′*) to the brain; the other *posterior*, or the *restiform body* (*c e*), which may be called the *peduncle* of the cerebellum, because it is exclusively intended (*n*) for that organ; the former is composed of white bundles, which emerge from the interior of the spinal cord, and the latter of the anterior columns, and of the remaining white bundles of the cord. The olivary bodies (*d*) are situated between these two sets of white fibres.

When, by means of the stream of water, the anterior pyramids and the restiform bodies have been removed, it is seen that each half of the medulla oblongata is formed principally of a very dense nucleus, consisting of a mixture of grey and white substances. This *nucleus*, or *fasciculus of reinforcement of the medulla oblongata*, which we shall call the *unnamed fasciculus* (*faisceau innominé*) of the medulla, commences opposite the decussation of the pyramids by a narrow extremity, increases in size as it proceeds upwards, passes above (*l*, *fig.* 274.) *i. e.* deeper than the pons, and becomes continuous as we shall afterwards see with the corresponding optic thalamus. Each half of the medulla oblongata has its fasciculus of reinforcement, of which the *internal surface*, viz. that turned towards the middle line, corresponds to the fasciculus of the opposite side; but is separated from it by the white fibres (*o*, *fig.* 274.) already described (p. 941.) as passing horizontally from before backwards, in the median line of the medulla. The *posterior surface* of these fasciculi (*p*, *fig.* 271.) constitutes the anterior wall of the fourth ventricle. The corresponding peduncles of the cerebellum, or the restiform bodies, embrace them on the outside, and form, as it were, grooves for them.

On examining thoroughly the internal or median surface of each reinforcing fasciculus of the bulb, it is found that there are two vertical bands upon that surface, one anterior, the other posterior; and that the fibres which pass horizontally from before backwards, in the median line of the medulla oblongata, are situated between the bands of the right and left sides.

Each fasciculus of reinforcement is divided above into two parts, one of which forms the centre of the corresponding restiform body, whilst the other becomes continuous with the optic thalamus above the pons Varolii.

I have not alluded to the *olivary fasciculi* admitted by some anatomists, for the white bundles so called do not even come from the olivary body, but form the continuation of the lateral columns of the spinal cord, which embrace the olivary bodies on the outer side, without being reinforced by any bundles derived directly from them.*

* [The bundles, named faisceaux innomminés in the text (*fasciculi teretes* of some other authors), which M. Cruveilhier describes as taking their rise at the lower end of the medulla oblongata, are more generally considered to be prolonged from the lateral columns of the cord: and on comparing the statements of recent inquirers concerning the anatomy of the medulla oblongata, the following appears to be the arrangement which the columns of the cord undergo in passing through it, viz. the posterior columns (including the posterior median fasciculi, which correspond with the posterior pyramids) separate laterally from one another (*e*, *figs.* 273, 274.) and enter the cerebellum, forming the principal part of its inferior peduncle (*n*). The fibres of the lateral columns are disposed of in three ways: 1. a part of them cross the median plane to the opposite side (*w*, *fig.* 273.), and form the chief part of the pyramidal body (*b*) of that side; 2. another set join the inferior peduncle of the cerebellum; 3. the remaining fibres are continued along the floor of the fourth ventricle (*p*, *fig.* 271.) as the fasciculi innominati or fasciculi teretes. The anterior columns (*a*, *fig.* 273.) of the cord, on entering the medulla oblongata, are thrown aside by the decussating fibres coming from the lateral columns, and then one portion of each anterior column forms the outer part of the corresponding pyramid (*b*); another

Developement of the Spinal Cord.

As soon as the spinal cord has passed through its original condition of an almost transparent pulp, it assumes the appearance of a lamina, the edges of which are rolled back upon themselves, so as to inclose a canal, continuous with the cavity of the fourth ventricle, which might be regarded as the expanded extremity of the canal. This canal is narrowed along the middle by the reflection of the pia mater into it: it is thus converted into two canals, the walls of which are at first thin, but afterwards increase in thickness, gradually encroach upon the caliber of the canals, which finally disappear between the sixth and seventh month. At this period a thin, white, outer layer covers the whole medulla: the posterior median columns are very large, and of a white colour, whilst the antero-lateral columns are still semi-transparent, the grey matter is soft and diffluent, like a pulp; and, by the slightest insufflation, a canal may be formed along the centre of each half of the cord.

The spinal cord occupies the whole length of the vertebral canal, until the third month; but after this time, its lower extremity becomes relatively higher up to the period of birth, when it corresponds to the second lumbar vertebra.

The spinal cord is larger, in proportion to the brain, during the early periods of fœtal life, than afterwards. The more rapid developement of the brain, at later periods, gives that organ the advantage.

From studying the developement of the spinal cord, Tiedemann infers that the white substance exists before the grey, and therefore that the latter cannot be the nutritious organ or matrix of the white substance, as Gall had affirmed. It is quite certain, that the white parietes of the medullary canal are developed previously to the grey matter.

Developement of the Medulla Oblongata.

During the first three months of intra-uterine life, the upper limit of the medulla oblongata is not defined, because there is no pons Varolii. The fœtal brain, therefore, in this condition, resembles the brains of birds, reptiles, and fishes. The transverse fibres of the pons make their appearance during the fourth month, and the upper limit of the medulla oblongata is then established.

The two halves of the medulla oblongata are perfectly distinct, and each half is divided into three columns: one for the brain properly so called, viz. the anterior pyramidal bundle; another for the tubercula quadrigemina, which may be called, with Tiedemann, the olivary bundle, remembering at the same time that this term has a very different meaning from what was attached to it by Gall; and a third or cerebellar bundle, which is the restiform body.

The anterior pyramidal bodies are, at first, flattened like those of mammalia, but during the latter months they acquire their characteristic size and prominence. In the medulla oblongata of a fœtus, from the seventh to the ninth month, the anterior pyramids are of a reddish grey colour, whilst the anterior columns of the spinal cord are as white as they appear afterwards. Those pyramids, therefore, are not the continuation of the anterior columns of the cord.

The decussation of the pyramids is perfectly distinct after the fourth week of fœtal existence.*

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portion (*c, fig.* 274.) passes partly behind and partly on the outer side of the olivary body, and is then chiefly continued into the fillet (*h*); the remaining part passes into the cerebellum, joining its inferior peduncle (*n*). The connexion of the cerebellum with the anterior columns of the cord was pointed out by Mr. Solly. (*Phil. Trans.* 1836, p. 567.) Arnold describes the posterior pyramids (*fasciculi graciles*) as passing into the crura cerebri. For further details on the anatomy of the medulla oblongata, the reader is referred to Arnold's *Bemerkungen über den Bau des Hirns und Rückenmarks*. Zurich, 1838; also his *Icones Anatomicæ*, fasc. i.; and to a paper by Dr. J. Reid in the *Edin. Med. and Surg. Journ.* for January, 1841.]

* [The fourth or fifth month, according to Tiedemann; though in one part of his work "week" has been by an error printed for "month."

The olivary bundles of Tiedemann, which are situated to the outer side of the anterior pyramids, and like them traverse the pons, gain the sides of the tubercula quadrigemina, beneath which they form an arch, which constitutes the upper wall of the aqueduct of Sylvius. The olivary bodies which are wanting in birds, reptiles, and fishes, do not appear until the end of the sixth or the commencement of the seventh month of fœtal life.

The cerebellar bundles, or restiform bodies, are perfectly distinct from the preceding. The small mammillated bundles which bound the sides of the posterior longitudinal groove can also be distinguished in the fœtus.

Comparative Anatomy of the Spinal Cord.

Mammalia. The spinal cord of mammalia precisely resembles that of the human subject: its length, its size, its enlargements, are exactly proportioned to the size and activity of the muscles, and to the sensibility of the organs with which it is connected by means of the nerves.

Birds. The spinal cord in birds is proportionally both longer and larger than in other animals; and this has reference to the enormous muscular effort required in flying. It presents two great enlargements; one of these corresponds to the wings, and the other, which is larger, and contains a ventricle, corresponds to the lower extremities; this ventricle was known to Steno, who described it under the name of the *rhomboidal sinus.*

According to Nicolai (*Dissertatio de Medullâ Spinali Avium.* Halle, 1811) and Tiedemann, the spinal cord of birds contains a central canal, which is lined by a thin layer of grey matter, not only in the embryo, but also in the adult.

Reptiles. In all reptiles the spinal cord contains a canal, which is lined, according to Tiedemann, by a thin layer of grey substance. In the batrachian reptiles (the toad, frog, &c.) the spinal cord occupies only the anterior or upper part of the vertebral canal. M. Desmoulins says (t. i. p. 187.) that the grey matter in these species surrounds the white substance. This opinion appears to me to be erroneous.

In ophidian reptiles (serpents) the spinal cord occupies the whole length of the vertebral canal; there is no grey matter *, but its place is occupied by a fluid, so that each half of the medulla contains a canal.

In the saurians (crocodiles, lizards) the spinal cord is slender, of almost uniform size throughout, and occupies the whole length of the vertebral canal.

The spinal cord of the chelonian (tortoises, &c.) is the most remarkable of all, as regards its shape, and is peculiarly illustrative of the law which regulates the dimensions of this organ. There are three fusiform enlargements separated from each other by two very narrow portions; the middle enlargement corresponds to the upper extremities, and the inferior one to the lower extremities; the first constriction corresponds to the neck, the second to the thorax.

Fishes. In all *fishes* the spinal cord occupies the entire length of the vertebral canal. It is of uniform size in its anterior five sixths, but diminishes like a cone in the posterior sixth. There is no grey matter †, so that the cord is hollow. According to Arsaky (*Dissert. de Piscium Cerebro*) and Tiedemann the medullary canal is lined by a thin layer of grey matter.

The lophius piscatorius, and the male tetrodon present remarkable anatomical peculiarities: in the lophius the spinal cord is diminished in size opposite the third cervical vertebra; all at once it becomes extremely slender, and then terminates in a point opposite the eighth cervical vertebra. Twenty-six pairs of nerves arise from the enlarged portion, and only five or six pairs from the slender portion. In the tetrodon there is no spinal cord, properly so

* [The spinal cord of serpents forms no exception to the general rule; grey matter has been recognised in it, as in the cord of other vertebrated animals. The same is true of fishes. (See Leuret, *Anatomie Comparée du Système Nerveux, &c.* Paris, 1839.)]

† See note, *suprà.*

called, or rather this part of the cerebro-spinal axis is reduced to a medulla oblongata, from which arise thirty-two pairs of nerves.

From these facts it follows, that the length and size of the spinal cord bear an exact proportion to the muscular power and sensibility of the parts supplied by it; and further, that the grey matter of the cord is not nearly so important as the white substance, since it is absent in a great number of species.*

Comparative Anatomy of the Medulla Oblongata.

In the *mammalia* the medulla oblongata is constructed upon the same plan as in the human subject, but the anterior pyramids are much smaller, and the olivary bodies appear to be completely effaced. The tubercula cinerea of Rolando exist only in man; in whom alone do we find those white streaks of medullary substance upon the anterior wall of the fourth ventricle, which are regarded as forming, at least in part, the origins of the auditory nerves.

The medulla oblongata of *birds* and *reptiles* presents no striking peculiarities. In the different species its size is always in proportion to that of the fifth, and especially the eighth pair of nerves, which take their origin from this part.

In *fishes* a peculiar pair of lobes correspond to the medulla oblongata; these lobes were for a long time erroneously supposed to be the lateral lobes of the cerebellum, and have thus led to much obscurity concerning the anatomy of the encephalon in these animals. Desmoulins calls them the lobes of the fourth ventricle; we shall call them the lobes of the eighth pair of nerves. In the ray and sturgeon this lobe is so highly developed, that it forms half of the encephalic mass. In the carp, besides the lateral lobes which are traversed by some white fibres, there is also a median lobe. Moreover, as a general rule, whenever the spinal cord has to furnish any nerves there is an enlargement, or a lobe. In the torpedo, in which the eighth pair of nerves are of enormous size, and supply the electrical organ, these lateral lobes are in an extraordinary degree developed. In the trigla there are certain small lobes behind the cerebellum, which correspond to the peculiar digitiform prolongations serving as organs of progression in the animals in question.

The olivary bodies are most highly developed in the human subject; they exist also, but are very small, in some mammalia; they disappear in birds, reptiles, and fishes. I consider the olivary bodies as lobes in a rudimentary state.

THE ISTHMUS OF THE ENCEPHALON.

General description and division. — The Pons Varolii and middle peduncles of the cerebellum — the peduncles of the cerebrum — the superior peduncles of the cerebellum and the valve of Vieussens — the corpora quadrigemina. — Internal structure of the isthmus, viz. of its inferior, middle, and superior strata. Sections. — Developement. — Comparative anatomy.

I shall, with Ridley, apply the term *isthmus of the encephalon* to that narrowed and constricted portion of the encephalic mass, which is situated between the cerebrum, cerebellum, and medulla oblongata, which corresponds to the free margin of the tentorium cerebelli, and comprises the pons Varolii and middle peduncles of the cerebellum, the peduncles of the cerebrum, the tubercula quadrigemina, the superior peduncles of the cerebellum, and the valve of Vieussens.

The isthmus of the encephalon is the common point of union between the three great divisions of the cerebro-spinal axis, viz. the medulla spinalis, the cerebrum, and the cerebellum. It contains within it the media by which they

* See note, p. 945.

all communicate, or, as it may be said, the elements of each reduced to their most simple expression.

It is of a cuboid form, and therefore presents six surfaces for our consideration:—

An *inferior surface* (*fig.* 276.), on which we observe the pons Varolii, or tuber annulare (*d*), the middle peduncles of the cerebellum (*m*), and the peduncles of the cerebrum (*f f*).

A *superior surface* (*fig.* 271.), which is covered by the superior vermiform process of the cerebellum, by the velum interpositum, and by the posterior border of the corpus callosum. In order to expose this surface, supposing the brain to be with its base upwards, the cerebellum must be turned forwards, and the pia mater should be separated, taking care to lift up with it the pineal gland. Proceeding from before backwards, the following parts come into view: the tubercula quadrigemina (*f g*), resting upon them the pineal gland (*c*), the superior peduncles of the cerebellum (shown cut at *r*; also *r*, *fig.* 272.), and the valve of Vieussens (*l*, *fig.* 271.).

The *lateral surfaces* (*fig.* 272.) are each divided into two distinct parts or stages, by a furrow which runs from before backwards (the lateral furrow of the isthmus); the inferior stage consists of the pons Varolii (*a*) and the middle peduncles of the cerebellum (*m*), whilst the superior is narrower, lies closer to the median line than the preceding, and presents a *triangular fasciculus* (*h*), having its base directed downwards, and its apex turned upwards, so as to reach the corresponding inferior quadrigeminous tubercle or testis (*g*).

The *anterior surface* of the isthmus is continuous with the optic thalami (*s*, *fig.* 272.).

The *posterior surface* is much narrower than the anterior, and is continuous with the base of the medulla oblongata.

We shall examine the several parts of the isthmus in the following order — the *pons Varolii* and *middle peduncles of the cerebellum, the peduncles of the cerebrum, the superior peduncles of the cerebellum, the valve of Vieussens, and the tubercula quadrigemina.* The *inferior peduncles of the cerebellum* have been already described with the rest of the medulla oblongata under the name of the *restiform bodies.*

The Pons Varolii and Middle Peduncles of the Cerebellum.

The *pons Varolii*, or *tuber annulare**, is that white cuboid eminence (*d*, *fig.* 276.), situated between the cerebrum and cerebellum, upon the base of the encephalon, and forming, as it were, its centre (mésocéphale, *Chauss.*; nodus encephali, *Soemm.*). From this centre, the several parts proceed as follows — backwards, the medulla oblongata (*e*); forwards, two thick white bundles, which pass into the brain, and form the *anterior* or *cerebral peduncles* (*f f*); laterally, two thick bundles, which enter the cerebellum, and are named the *posterior* peduncles or middle *cerebellar peduncles* (*m*).

The pons Varolii, the cerebral and cerebellar peduncles, and the medulla oblongata proper, are together called the *medulla oblongata* by some authors; several of the older anatomists, in fact, compared the pons to the body of an animal, of which the anterior peduncles represented the arms; the posterior, the legs; and the medulla oblongata proper, the tail; and hence the terms still in use of the *arms*, *legs*, and *tail* of the so-called medulla oblongata. It was Varolius who compared this part to a bridge, under which the several branches of a stream, supposed to be represented by the peduncles and the medulla oblongata, joined each other; hence the terms *pons Varolii* and *pons cerebelli.*

The pons is free below, but is blended above with the upper portion of the isthmus; it is bounded in front by the peduncles of the cerebrum, and

* The term tuber annulare is derived from the fact, that this part of the encephalon seems to embrace the several prolongations of the medulla oblongata like a ring.

behind by the medulla oblongata; and it is continuous, laterally, with the middle peduncles of the cerebellum (*m*), forming with them but one system of fibres; its lateral boundaries are, therefore, altogether artificial.

The *size* of the pons, which is very considerable in the human subject, is always in relation with the developement of the lateral lobes of the cerebellum; comparative anatomy, embryology, and the study of malformations completely establish this fact. *

Its *inferior surface* is covered by the pia mater, which can be easily stripped off; it rests upon the anterior part of the basilar groove, and slopes backwards and downwards like the inclined plane of that groove.

It presents along the median line a slight furrow, which is broader in front than behind, and corresponds to the basilar artery: this groove appears as if it were caused by the presence of the artery; nevertheless, I must say, that not unfrequently the basilar artery is found to deviate to one side or the other, or to be more or less tortuous, and yet that the median groove is as distinctly marked as usual.

I believe there is good ground for entertaining the opinion, that this groove results from the prominence of the anterior pyramids, which raise up the surface of the pons on each side of the median line.

The inferior surface of the pons presents certain transverse bundles of fibres, which appear to cross each other at very acute angles, and which, according to Rolando, may be divided into three sets: *superior bundles*, which turn upwards, to constitute the upper part of the middle peduncles of the cerebellum; *inferior bundles*, which pass transversely outwards; and *middle bundles*, which are directed obliquely downwards and outwards, pass in front of the inferior bundles, and then form the anterior border of the cerebellar peduncles. The origin of the fifth pair of nerves is between the superior and middle sets of fibres. Not unfrequently the middle bundles are not to be seen.

It follows, therefore, that the middle peduncles of the cerebellum are merely the transverse fibres of the pons condensed and twisted upon themselves. The pons and these peduncles of the cerebellum constitute one and the same system of fibres. We might therefore, with Gall, designate the pons and the middle peduncles of the cerebellum as the *commissure of the cerebellum*, or *corpus callosum of the cerebellum.*

The Peduncles of the Cerebrum.

The peduncles of the cerebrum (*f f*, *fig.* 276.), sometimes regarded as prolongations of the cerebrum to the medulla oblongata (*processus cerebri ad medullam oblongatam, ad pontem Varolii*), sometimes as the arms, legs, or thighs of the cerebrum (*brachia, crura, femora, cerebri*), and by others as prolongations of the medulla towards the cerebrum (*processus medullæ oblongatæ ad cerebrum*), are two thick, white, fasciculated columns, which arise from the anterior angles of the pons Varolii, and enter the substance of the cerebrum, after a course of about six lines.

They are cylindrical, and in contact with each other as they emerge from the pons, and they gradually increase in size, and become flattened as they advance forwards, upwards, and outwards. The optic tracts (*s* 2, *fig.* 272.) circumscribe and bound them in front.

Their size corresponds to that of the cerebral hemispheres. They are of equal dimensions in a well formed brain, but they are liable to become atrophied with their corresponding hemisphere, as I have had frequent occasion to observe.

Each of them is free below, and on its outer and inner side, but is blended

* Animals which have no lateral lobe of the cerebellum have no pons Varolii, and this part is small in such as have very small lateral cerebellar lobes. In a young girl ten years of age, who had no cerebellum, I found that the pons was also wanting.

above with the upper portion (*h i f g*, *fig.* 272.) of the isthmus of the encephalon.

Their white fasciculi are slightly divergent, and are often intersected at right angles by certain white tracts, some of which emerge from the testes and the valve of Vieussens, whilst others proceed from the internal surfaces of the peduncles themselves. This arrangement Gall and Spurzheim have named the *transverse interlacement of the great fibrous bundles* (see *fig.* 272.). Owing to the oblique and diverging direction of the cerebral peduncles there is left between them a triangular *interpeduncular space* (between *r* and *t*, *fig.* 276.), which is occupied in front by the corpora mammillaria or albicantia (*z*) and the tuber cinereum (*v*), and in which is observed behind two white triangular bundles, separated from the peduncles by a blackish line. We shall see that these interpeduncular bundles are merely the under-surface of the bundles of reinforcement of the medulla oblongata, or the "faisceaux innominés" (*l*, *fig.* 274.).

The Superior Peduncles of the Cerebellum and the Valve of Vieussens.

The *superior peduncles of the cerebellum* (*r*, *figs.* 271, 272. 280.) are more commonly known as the *processus cerebelli ad testes*, a name given to them by Pourfour Dupetit. I should observe, however, that this name sanctions an anatomical error; for the superior peduncles of the cerebellum do not go to the *testes* at all, but pass under them, and are covered by the corresponding lateral triangular bundle of the isthmus; they should rather be called *processus cerebelli ad cerebrum* (*Drelincourt*).

The inferior peduncles of the cerebellum consist of two lamellæ, which arise from the interior of the cerebellum, one on each side of the median line, pass upwards and forwards parallel to each other, and appear to be continuous with the testes.

Their *upper convex surface* is covered by the cerebellum (see *fig.* 280.), and is separated from it by a double layer of the pia mater. Their *inferior surface* is free, and assists in forming the upper wall of the aqueduct of Sylvius. Their external borders are each separated from the pons by a furrow, which we have already described under the name of *lateral furrow of the isthmus.* Their *internal* borders are connected together by means of the valve of Vieussens, which is distinguished by its colour from the peduncles.

Their *inferior extremities* pass deeply into the central white substance of the cerebellum.

The *valve of Vieussens* (*valvula magna cerebri*, *l*, *fig.* 271.; *v*, *fig.* 280.; *g* to *w*, *fig.* 282.) is a thin semi-transparent lamina, which occupies the interval between the two superior peduncles of the cerebellum; it is the *velum medullare* or *velum interjectum* of Haller.

Its *posterior surface* is concave, and is in relation above with the superior vermiform process; in its lower portion it adheres to the transversely notched imperfect lamella (linguetta laminosa, *Malacarne*), in which the superior vermis ends.

The *median line* of this posterior surface is marked by a line (*fig.* 271.), which Rolando considers as the trace of the line of junction between the two laminæ, of which, according to him, the valve consists.

The *anterior surface* is convex, and forms the posterior wall of the aqueduct of Sylvius (leading from *v* to *l*, *fig.* 282.).

The *borders* of the valve are not only in juxtaposition with the corresponding borders of the superior peduncles of the cerebellum, but appear to be continuous with them.

The *superior extremity* is narrow, and presents a transverse band, which may be regarded as the commissure of the superior peduncles of the cerebellum and of the fourth pair of nerves.

The *inferior extremity* is broad, very thin, and continuous with the central portion of the median lobe of the cerebellum (*w*).

The Tubercula Quadrigemina.

Dissection. Place the brain with its base upwards, turn the cerebellum forwards, and remove the pia mater.

The term *tubercula quadrigemina* or *bigemina* (corpora bigemina, *Soemmerring; optic lobes* of the lower animals) is applied to four tubercles (*f g f g, figs.* 271, 272.), situated regularly upon the upper surface of the isthmus, two on each side of the median line. They form two pairs; the anterior or superior (*f*) are the larger, and are called the *nates* (*eminentiæ natiformes*); the posterior or inferior (*g*) are the smaller, and are called the *testes* (*eminentiæ testiformes*).

These tubercles are placed between the cerebrum and cerebellum, and are situated above the peduncles of the cerebrum, and consequently upon a plane anterior to that of the pons, and cannot consistently be named the *tubercles of the mesocephalon*, as was done by Chaussier. The anterior part of the *aqueduct of Sylvius* passes beneath them (*f g, fig.* 282.), and establishes a communication between the third (*l*) and fourth (*v*) ventricles.

They are comparatively small, indeed merely rudimentary in the human subject, for their developement in the animal series is inversely as that of the cerebrum and cerebellum. The space which they occupy is a parallelogram of ten lines by eight.

The *anterior* tubercles are always larger than the posterior *; they are of a grey colour, oblong, ellipsoid, and diverging; their longest diameter is directed obliquely forwards and outwards. The *posterior* tubercles are smaller, and more detached; they are almost hemispherical, and of a white colour; but not so white as the fasciculated medullary substance.

A furrow, curved like a parabola opening forwards, separates the anterior from the posterior tubercles. The antero-posterior furrow along the median line separates the tubercles of the right from those of the left side. From this furrow a small, greyish, and tolerably dense cord proceeds backwards, and descends perpendicularly upon the valve of Vieussens, or rather upon the transverse commissure by which it is surmounted, and then divides into two or three branches. This cord might be named the *pillar of the valve of Vieussens* (*columella, frenulum*).

The *lateral triangular bundle* (*h, figs.* 271, 272.) *of the isthmus* terminates in the posterior tubercle. This fasciculus, which was pointed out by Reil ("schleife," lemniscus, fillet), Tiedemann, and Rolando, who described it as arising from the olivary bodies, presents an *anterior* border, which is directed obliquely forwards and outwards, proceeds along the anterior tubercle, and terminates in a small body, called the *corpus geniculatum internum* (*i, figs.* 271, 272.). Its *posterior* border inclines downwards, backwards, and outwards, and forms a slight prominence above the superior peduncle of the cerebellum, which is covered by it. Its *base* corresponds to the lateral groove of the isthmus, which separates it from the pons and the peduncle of the cerebrum. Its *apex* extends to the corresponding posterior tubercle or testis. The anterior tubercles or nates are continuous with the optic thalami (*a, fig.* 271.), being separated from them by a slight depression. Some white fibres proceed from the anterior extremity of these tubercles, and, as we shall afterwards see, form a thin layer above the corresponding corpus geniculatum externum (*j*), and assist in the formation of the optic nerves. These white bands are generally proportioned to the size of the nates. †

* The relative size of the tubercula quadrigemina varies somewhat in different animals. The anterior tubercles are much larger than the posterior in ruminants, solipeds, and rodentia; they are smaller than the posterior in carnivora — in the dog, for example.

† They are very large in the sheep: it appears that it was chiefly from the anatomy of the brain in this animal that Gall founded his opinions as to the optic nerves, which he regards as

The Internal Structure of the Isthmus of the Encephalon.

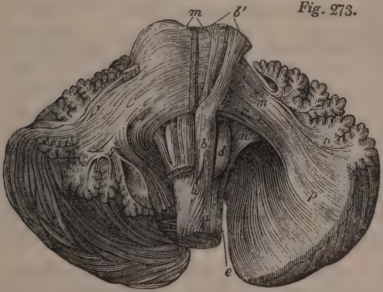
Dissection. By antero-posterior and transverse sections of the isthmus. The parts to be examined by laceration, by submitting them to the action of a stream of water, and also after they have been hardened in alcohol, or by being boiled in oil, or a solution of salt.

The internal structure of the isthmus presents three very distinct strata placed one upon the other: an *inferior*, formed by the pons, the middle peduncles of the cerebellum, and the fasciculated portion of the peduncles of the cerebrum; a middle stratum, formed by the prolongation of the bundles of reinforcement of the medulla oblongata; and a *superior* stratum, which consists of the triangular lateral bundles of the isthmus, the superior peduncles of the cerebellum, the valve of Vieussens and the tubercula quadrigemina.

Internal Structure of the Pons and the Peduncles of the Cerebellum.

It has been stated that the lower surface of the pons presents some white transverse fibres (see left side, *fig.* 273.), which twist upon each other to form the middle peduncles of the cerebellum. On making a very superficial incision into the pons, we find beneath the external layer of white matter, which is very thin behind, and a little thicker in front, a greyish yellow substance, which is traversed by the transverse fibres of the pons, so that the part (*m*, *fig.* 274.) has a striated appearance.

Fig. 273.



If the handle of the scalpel be passed beneath the anterior border of the pons, so as to remove all that part which projects beyond the level of the peduncles of the cerebrum, it will be seen that the pons is traversed longitudinally by certain white bundles of fibres (*b′*, *figs.* 273, 274.); and if, moreover, the handle of the scalpel be insinuated beneath the posterior border of the pons, and all that part be removed which projects beyond the pyramidal bodies of the medulla oblongata, these white longitudinal bundles which traverse the pons are found to be the prolongation of the pyramids (*b*), and are themselves continuous with the peduncles of the cerebrum (*n*, *fig.* 282.). By thus separating the pons into very thin horizontal layers it will be found that the longitudinal (*b′*) and transverse (*m*) fibres form several alternate layers, above which we arrive at the middle stratum of the isthmus.

The peduncles of the cerebrum are continuous with the longitudinal fibres of the pons, and the middle cerebellar peduncles with the transverse fibres of the same part; the grey matter of the pons extends into the substance of the latter, and gives them a striated appearance. At the boundary between the pons and the middle peduncles of the cerebellum there is on each side a very considerable longitudinal bundle, which forms the origin of the fifth nerve, and which therefore does not belong to the anterior pyramidal bodies.*

The absolute continuity of the anterior pyramids with the peduncles of the

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arising from the tubercula quadrigemina. This opinion is very doubtful as far as concerns the human subject.

* The most anterior and the most posterior transverse fibres of the pons have a very peculiar arrangement; the anterior are inflected (*o*, *fig.* 282.) between the peduncles of the cerebrum, and completely occupy the interval between them; so that each of these peduncles is embraced by a distinct ring formed by the fibres of the pons; and, again, the most posterior fibres of the pons dip between the anterior pyramids, each of which is also embraced by a distinct ring.

cerebrum, though the pons may be regarded as a type of the structure of the nervous centre. The two sets of fibres are intermixed in the pons, so as to intersect each other at right angles, but they maintain their individuality. *

The pons presents neither a raphé nor a septum in the median line: the fibres of the right half are continuous with those of the left. The white fasciculated fibres (*b′*) of the peduncles of the cerebrum, which are continuous with the anterior pyramids (*b*), form part of the inferior stratum of the isthmus; these fasciculated fibres are parallel and perfectly white, without any intermixture of grey matter.

Internal Structure of the Middle Stratum of the Isthmus.

When the pons, or in other words the successive layers of the inferior portion or stratum of the isthmus, have been removed, the middle stratum is exposed. This may be very easily displayed in a brain that has been well

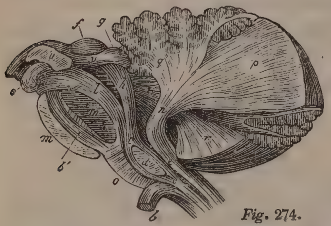


Fig. 274.

hardened in alcohol. It is then seen that this middle stratum is formed by a prolongation of the fasciculi of reinforcement (*faisceaux innominés*) of the medulla oblongata, which becomes enlarged in passing above the pons, and still more so opposite the peduncles of the cerebrum, above which we shall trace them presently. This prolongation (*l*, *fig.* 274.) then passes through the pons at right angles. It was doubtless to illustrate this arrangement that Varolius described the medulla when viewed from below as passing beneath the pons like the water of a canal under a bridge. This reinforcing bundle, pointed out by Rolando (*Recherches sur la Moelle Alongée*, 1822), under the appellation of the middle fasciculus, has been correctly represented by Mr. Herbert Mayo.

Those portions (*c*, *fig.* 269. A) of the bundles of reinforcement which correspond to the peduncles of the cerebrum are separated from the superficial part of the peduncles themselves (*a*) by a layer of black or blackish matter (*b*): opposite the peduncles, these two bundles are intimately united †, but they soon diverge to enter the optic thalami. Are they simply in juxtaposition, or do they interlace at the point in which they appear to be blended? I am inclined to believe that they do interlace; but I have not yet been able to demonstrate this clearly, because they do not consist of very distinct bundles.

Internal Structure of the Upper Stratum of the Isthmus.

The *superior peduncles of the cerebellum* are fasciculated: their lower extremities (*r*, *fig.* 274.) assist in forming the central nucleus of the cerebellum; their upper extremities (*r′*) expand into a great number of fibres, some of which terminate upon the anterior wall of the fourth ventricle, on each side of the median line, whilst others form a *loop* below the tubercula quadrigemina.

Structure of the tubercula quadrigemina. Reil, who first examined the structure of the tubercula quadrigemina, considers them as consisting of four

* The continuity of the pyramids with the peduncles of the cerebrum, through the inferior portion of the pons, was accurately described and figured by Varolius (*De Nervis Opticis nonnullisque aliis*, 1573), by Vieussens (*Neurographia Universalis*, tab. 16.), by Morgagni (*Adversaria Anatomica*, v.), and by Vicq d'Azyr. Vieussens showed this continuity by lacerating the pons. Vicq d'Azyr showed it by successively removing the thin layers of the pons by means of a cutting instrument. The plates given by Gall surpass those of his predecessors in execution, but not in a scientific point of view.

† [They here constitute the so-called *integumentum* (*c*, *fig.* 269. A), the black substance is called the *locus niger* (*b*), and the superficial part of the peduncle is named the *crust* or *basis* (*a*).]

rounded masses of grey matter, placed upon the radiated fibres of a white bundle, which spreads out beneath them. This white bundle (forming part of the bundle *h*, *fig.* 274.), which he calls the *fillet* or *loop*, is derived (*c*), according to him, partly from the anterior pyramidal, and partly from the olivary body (*d*). It appears to me to be nothing more than the above-mentioned loop formed by the superior peduncles of the cerebellum, below the tubercula quadrigemina.

The tubercula quadrigemina themselves seem to me to be rather of a laminated than of a fasciculated structure. Mayo represents them as having a fasciculated texture.

The *triangular lateral fasciculus of the isthmus* (*h*, *fig.* 272.) passes in one direction between the upper and middle strata of the isthmus, and in another it may be traced (forming the other part of the bundle, *h*, *fig.* 274.) downwards as far as the olivary body. The anterior fibres extend from the testis (*g*) to the corpus geniculatum internum (*v*), pass beneath that body, and penetrate into the interior of the optic thalamus. This triangular fasciculus forms a layer upon the superior peduncle of the cerebellum, from which it is perfectly distinct.

Sections of the Isthmus of the Encephalon.

A vertical section made from before backwards through the median line of the isthmus will give an excellent view of its three portions or strata: the section should include the medulla oblongata (see *fig.* 274.). Upon it are seen the white and grey striated mass (*m b′ m*) which constitutes the pons, the reinforcing fasciculus (*l*) of the medulla oblongata becoming much thicker opposite the peduncles of the cerebrum than in the pons.

Transverse vertical sections will display the arrangement of the pyramidal bodies and the reinforcing fasciculi as they pass from the medulla oblongata into the isthmus. In these sections a thick bundle belonging to the fifth nerve is always seen.

Sections of the tubercula quadrigemina show that they are neither distinct from each other, nor from the external and internal corpora geniculata, nor from the reinforcing fasciculi of the medulla oblongata; but that these latter fasciculi and the tubercula quadrigemina form a single system, surmounted by masses of nervous matter, which are the tubercles themselves.

Developement of the Isthmus Encephali.

The developement of the pons and of the peduncles of the cerebellum is in relation with that of the cerebellum; and the developement of the cerebral peduncles with that of the cerebrum.

In the embryo of two months, the tubercula quadrigemina consist merely of two laminæ, which curve upwards and outwards, and become united at the end of the third month.

At this period the tubercula quadrigemina of the human subject are in the same condition as those of the lower animals. They are as yet indeed only two in number, one on each side of the middle line; and they are hollow as in birds. At first they are completely exposed, but are gradually covered by the hemispheres of the cerebrum, as those parts are prolonged backwards.

The transverse groove which divides the hitherto single pair of tubercles into an anterior and a posterior tubercle on each side, does not appear until about the sixth month, at which time the cavity in their interior has been obliterated by the thickening of their parietes.*

* In a fœtus of seven months I found the tubercula quadrigemina not yet divided into the nates and testes.

Comparative Anatomy of the Isthmus.

The *pons Varolii and middle peduncles of the cerebellum* exist only in the human subject and in mammalia generally; these structures, which may be regarded as forming the commissure of the cerebellum, are developed exactly in proportion to the size of the lateral lobes of that organ; so that they attain their utmost developement in the human subject, and are smallest in rodentia. The pons and cerebellar peduncles do not exist in the remaining three classes of vertebrata (birds, reptiles, and fishes), because those animals have no lateral lobes of the cerebellum.

The *tubercula quadrigemina* are less developed in man than in the lower animals. It may even be said, that the developement of these tubercles is inversely in proportion to that of the lateral lobes of the cerebellum and the hemispheres of the cerebrum.

The anterior tubercles are a little larger than the posterior in the human subject: in the ruminants, solipeds, and rodentia, on the contrary, the anterior tubercles are twice or three times as large as the posterior. In the carnivora the posterior are somewhat larger than the anterior.

They are covered by the cerebrum in the human subject and the highest orders of mammalia, but are in a great measure exposed in the rodentia and cheiroptera.

In birds, reptiles, and fishes, the tubercles are only two in number (the *tubercula bigemina*), and attain their maximum developement: sometimes they are even larger than the cerebral hemispheres; they are hollow, and form true lobes, which are called the *optic lobes*, because in fact the optic nerves arise exclusively from them.

In *birds*, the optic lobes are situated at each side of the base of the cerebrum. The optic lobes of birds are not the thalami optici, as was at first believed: in this class of animals the optic thalami are thrown forwards.

In *reptiles*, the tubercula quadrigemina consist, as in birds, of two large, ovoid, and contiguous lobes.

In *fishes*, it is extremely difficult to determine what are the tubercula quadrigemina; so much so, indeed, that the lobes of which they are composed, have been taken sometimes for the cerebral hemispheres, and sometimes for the optic thalami. M. Arsaky (*De Piscium Cerebro*) has successfully refuted both of these errors.

THE CEREBELLUM.

General description.—External characters and conformation—furrows, lobules, laminæ, and lamellæ.—Internal conformation—the fourth Ventricle, its fibrous layers, its inferior orifice, and its choroid plexus.—Sections of the cerebellum, vertical and horizontal.—Examination by means of water, and of the hardened cerebellum.—General view of the organ.—Developement.—Comparative anatomy.

The *cerebellum* (παρεγκεφαλις, *Aristotle; l l, fig.* 276.; *h h, fig.* 280.), or little brain, is that part of the encephalon which occupies the right and left inferior occipital fossæ. It exists in all animals which have a cerebrum and spinal cord, and therefore in all the vertebrata.

Cases of congenital absence of the cerebellum are extremely rare.*

Though for a long time neglected, the anatomical examination of the cerebellum was commenced with considerable talent by Petit of Namur (*Lettre d'un Médecin des Hôpitaux du Roi.* Namur, 1710) and Malacarne (*Encefalo-*

* Vide Anat. Pathol. avec fig. for a case of absence of the cerebellum.

tomia nuova universale. Torino, 1780). Vicq d'Azyr and Chaussier have described its external conformation with extraordinary accuracy; and Reil, Gall, and Rolando, have more particularly investigated its structure.

The External Characters and Conformation of the Cerebellum.

Situation. The cerebellum is enclosed between the inferior occipital fossæ and the process of the dura mater, called the tentorium cerebelli. It is placed (see *fig.* 282.) at the top of and behind the spinal cord, and the isthmus of the encephalon. It is covered by the cerebrum in the human subject only, whence the name *cerebrum inferius.* It is posterior to the brain in the lower animals, and is therefore called *cerebrum posterius.*

The dura mater, the arachnoid, and the pia mater, form a three-fold investment around it, the arrangement of which has been already described.

Size and weight. The cerebellum is larger in man than in any other species. It has been stated by Cuvier, that its size in the human subject is so exactly proportioned to that of the brain, that correct tables may be formed of their relative weights; but it appears to me that facts are opposed to this view.

The mean weight of the cerebellum, including the pons Varolii and medulla oblongata, is from four to five ounces; the proportion between the cerebrum and cerebellum may be estimated approximately to be as 7 to 1.*

According to Gall and Cuvier, the cerebellum of the female is proportionally larger than that of the male. Gall believes that its size is in a direct ratio with the energy of the generative function; and that this is indicated externally by the relative size of the inferior occipital protuberances.†

The cerebellum is proportionally much smaller in the infant than in the adult; the relation between the cerebrum and cerebellum in the infant is as 20 to 1.

Density. The consistence of the cerebellum has been much studied by anatomists, who are far from being agreed upon this subject. The great difficulty depends upon the want of accurate means of estimating its consistence. In fact, it may be readily conceived, that the conversion of its substance into a pulp by letting weights fall upon it from a determinate height, is at once a most inconclusive and almost inapplicable method of ascertaining the point. Another source of difficulty consists in the fact, that the cerebellum is not homogeneous; so that results obtained in reference to the grey matter, do not apply to the white substance. Out of fifty cerebella which Malacarne compared with the corresponding brains, twenty-three were softer than the brains in both the medullary and cortical substances; in thirteen the cortical substance was equally firm, but the medullary substance more consistent and elastic than that of the brain; ten were more dense in texture, and the remaining five were much harder than the corresponding brains. In some cerebella, one of the hemispheres was much more firm than the other.

The results of my observations are, that the medullary centre of the cerebellum is of a firmer consistence than that of the cerebrum; that the grey substance of the cerebellum is softer than that of the cerebrum; and that the grey substance of the former becomes softened in the dead body with such

* Chaussier says, "In a considerable number of comparative experiments we sometimes found that the adult cerebellum was $\frac{1}{6}$th or $\frac{1}{7}$th, and at other times, but rarely, $\frac{1}{10}$th or $\frac{1}{11}$th the weight of the cerebrum. In the infant, at birth, we found it to be $\frac{1}{13}$th, $\frac{1}{14}$th, $\frac{1}{17}$th, $\frac{1}{21}$st, $\frac{1}{26}$th, and, in one case, even $\frac{1}{33}$d the total weight of the brain." (*De l'Encéphale*, p. 77.)

† In my opinion this idea can only be regarded as an ingenious hypothesis. The aptitude for the generative act is not dependent upon the cerebellum, for all invertebrate animals are destitute of this organ; and in certain vertebrata, where the generative orgasm is quite remarkable, the cerebellum is extremely small. Some observations, however, are quoted, which appear to show that diminution of the occipital protuberance has followed extirpation of the corresponding testicle: but it must first be proved that these observations are correct; for example, that the inequality of the occipital protuberances did not exist previously to the castration.

extreme rapidity, that it is difficult to meet with a cerebellum in which this substance is in the normal state.

Form. The general outline of the cerebellum is that of an ellipsoid flattened from above downwards; its long diameter is transverse, and measures from three and a half to four inches; its antero-posterior diameter is from two to two and a half inches, and its vertical diameter two inches in the thickest part, and about six lines in the thinnest part, that is at its circumference. The figure of the cerebellum may also be compared to that of a heart on playing cards, the notch of which is directed backwards, and the truncated apex forwards; or rather, as was done by the old anatomists, to two flattened spheroids, united together at their points of contact.

The cerebellum is perfectly symmetrical, but yet a marked difference between the right and left half of this organ is not unfrequently observed.*

The cerebellum presents for our consideration an upper and a lower surface, and a circumference.

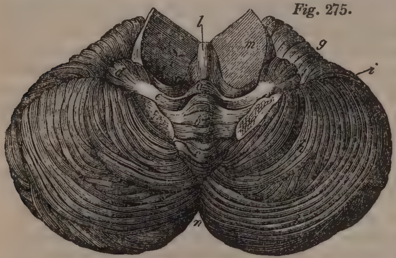
The *upper surface* (*h h*, *fig.* 280.) presents along the median line an antero-posterior eminence (*d*), which is rather prominent in front, but gradually disappears as it extends backwards: it is named the *superior vermiform process* (*vermis superior*). This eminence, which covers the valve of Vieussens and the tubercula quadrigemina, should be regarded, as Malacarne states, as the upper part of the *median lobe of the cerebellum.*

On each side (*h h*), the upper surface of the cerebellum forms an inclined plane. This surface is separated from the posterior lobe of the cerebrum by the tentorium cerebelli.

The *lower surface* of the cerebellum (*figs.* 275, 276.) is received into the concavity of the occipital fossæ, to which it is exactly fitted: it is divided into two rounded lateral halves (*h*, *fig.* 275.), the lobes of the cerebellum, by an antero-posterior fissure (*a* to *n*), the *great median fissure of the cerebellum* (vallecula, *Haller*).

The back part of the cerebellum is completely subdivided by this fissure (see *fig.* 282.), which receives the falx cerebelli; in front, the fissure opens into a wide furrow, into which the medulla oblongata is received (see *fig.* 276.); in the middle of the fissure is a lozenge-shaped interval, at the bottom of which is seen the base of a pyramidal eminence (*a b c*, *fig.* 275.), divided transversely into rings like a silkworm, and named accordingly by the older anatomists the *inferior vermiform process* (*vermis inferior*, *pyramid* of Malacarne). This eminence is developed into four prolongations or branches, arranged in the form of a cross; the posterior prolongation (*c*) is tapering, and occupies the back part of the great median fissure; the two lateral processes dip (on each side of *b*) into the adjacent portion of the fourth ventricle; and the anterior (*b*) tapers from behind forwards, and terminates in a mammillary enlargement (*a*), which is free and projects into the fourth ventricle. It has been unnecessarily distinguished from the rest of the inferior vermiform process by Malacarne and Chaussier, under the name of the *laminated tubercle of the fourth ventricle* (*tubercle lamineux du quatrième ventricule*). †

Fig. 275.



* In four cases which have come under my own observation, atrophy of the right hemisphere of the cerebrum co-existed with atrophy of the left hemisphere of the cerebellum; I am therefore led to conclude, that there are certain intimate relations between the opposite hemispheres of these two portions of the encephalon.

† [The inferior vermiform process is usually described as consisting of three portions — the *pyramid* (*c*, *fig.* 275.), the *uvula* (*b*), and the *nodulus* (*a*).]

The inferior vermiform process is merely the lower part of the *median lobe of the cerebellum*, of which the superior vermis constitutes the upper part. The superior vermis is continuous, without any line of demarcation, with the two hemispheres of the cerebellum, so that the upper part of that organ appears undivided. The inferior vermis, which seems at first sight to be intended to separate the two hemispheres, nevertheless forms the means of connexion between them, as may be easily seen by drawing them apart from each other.

The *circumference* of the cerebellum is somewhat elliptical, or rather resembles the heart upon playing cards; behind and in the middle line it presents a *notch* (*n*), between the convex margins of which a triangular interval is left, into which the falx cerebelli and the internal occipital crest are received. At the bottom of this notch the surface of the cerebellum is transversely grooved; this part unites the superior to the inferior vermiform process, and belongs to the median lobe of the cerebellum.

The rounded margins of the *notch* are continuous with the circumference of the cerebellum. In front, the circumference of the cerebellum appears to be formed by the pons Varolii (*d*, *fig.* 276.) and middle cerebellar peduncles (*m*), which are in relation with the posterior surface of the petrous portion of the temporal bones, and are therefore straight, and form a truncated angle, which projects forwards, and corresponds to the pons Varolii.

All the bundles of fibres which connect the cerebellum with the cerebrum and spinal cord enter at the anterior part of its circumference: thus, besides the middle peduncles of the cerebellum, we find in this situation its superior peduncles (*r*, *fig.* 272.), or *processus ad testes*, and its inferior peduncles (cut at *n*), or *processus ad medullam oblongatam*, to which we shall presently return.

The Furrows, Lobules, Laminæ, and Lamellæ of the Cerebellum.

The whole surface of the cerebellum is traversed by curved lines or furrows, which are for the most part concentric and horizontal, but not very regular.

These furrows are not parallel, but are inflected towards each other, and intersect at very acute angles.

They may be divided into four sets, according to their depth. The first set of furrows are the deepest: they reach as far as the central nucleus, and divide the cerebellum into *segments* or *lobules* (*g*, *h*, *l*, *fig.* 275.).

These segments are divided into *secondary segments* by the second set of furrows.

The secondary segments are again subdivided into *laminæ* or *folia*, and these laminæ into *lamellæ*, by two sets of yet smaller furrows.

Pourfour du Petit, Malacarne, and Chaussier have studied the segments, laminæ, and lamellæ of the cerebellum with great care, and have even counted them. The differences in their results* are not so much a proof of varieties in the structure of the organ, as of the want of some uniform method of enumeration.

The segments which occupy the circumference of the organ are the largest: they represent segments of an ellipsoid, and are very broad in the middle, and narrowed at each extremity. The segments of the upper surface are concentric, and their curvature corresponds to that of the entire cerebellum. The segments of the lower surface are also concentric in each half or lobe of the cerebellum, but the curves of one side are independent of those of the other.

The laminæ or folia of the cerebellum are applied to each other like the leaves of a book; they are separated from each other in their whole length,

* Winslow admitted 3 lobules, Collins 6, Pourfour du Petit 15, Malacarne 11, and Chaussier 16. Chaussier counted 60 laminæ, and from 600 to 700 lamellæ; Malacarne had previously counted from 700 to 800 lamellæ. It is a very curious fact that Malacarne only found 324 lamellæ in an individual labouring under mental alienation.

and are attached to the rest of the cerebellum by their adherent borders only. The lamellæ, however, are arranged in a different manner, for they pass from one lamina to another, and even from segment to segment. In fact, if the segments of the cerebellum be drawn asunder, the furrows between them are seen to be traversed obliquely by a great number of lamellæ, which extend from one segment to another.

The arrangement of the segments, laminæ, and lamellæ in the median line deserves particular attention. Opposite the superior vermiform process, they are not interrupted, but are merely bent slightly, so that the middle portion of each of the anterior segments is, as it were, drawn forwards, so as to describe a curve, having its concavity turned backwards. Upon this surface some slight peculiarities are observed in the arrangement of the parts. Along the median line there seems, indeed, to be an interchange of laminæ and lamellæ, some of each of which become thin, and end in points from which others appear to originate.

Opposite the inferior vermiform process the two hemispheres of the cerebellum are connected together by means of the lateral prolongations of that process. But in front, *i. e.* opposite the medulla oblongata, the two hemispheres of the cerebellum are perfectly distinct from each other (see *fig.* 275.). From these facts we may estimate to what extent the comparison is correct, which was drawn by Haller between the superior vermiform process and the corpus callosum.

At the back part of the cerebellum, opposite the notch in that situation, the two hemispheres are connected by means of certain small transverse rings, of which we have already spoken.

The superior and inferior vermiform processes and the portion situated at the bottom of the notch constitute together the *middle lobe of the cerebellum*, which Gall and Spurzheim named the *primitive* or *fundamental part of the cerebellum*, because it exists in all vertebrata, and because in a great number of them (as in birds, reptiles, and fishes), where the lateral lobes of this organ are altogether wanting, it constitutes the entire cerebellum. It is well to add, that the lateral lobes are relatively larger, and the median lobe smaller in man than in other mammalia.

A rudimentary median lobe and very large lateral lobes are the characteristics of the human cerebellum, whilst a very large median lobe and rudimentary lateral lobes form the characters of the cerebellum of the lower animals.

All the segments of the cerebellum, of which there are from ten to twelve, might with propriety be distinguished by particular names. The following segments, however, require special mention: the *segment* or *lobule of the circumference* (*l*, *fig.* 275.), which is the largest; the *lobules of the medulla oblongata* (lobuli medullæ oblongatæ), which are situated behind that part (see *fig.* 276.), are concave on their internal surface, which is accurately adapted to the medulla, and convex on their external and posterior surface, which dips slightly into the foramen magnum. These lobules (removed from *f*, *fig.* 275.), which have been noticed by all anatomists, are separated from one another by the inferior vermiform process (the uvula, *b*), and each of them terminates in front and on the inner side by a mammillated extremity (called the amygdala or tonsil), which partially fills up the fourth ventricle. The other inferior segments of each lobe of the cerebellum describe concentric curves around this segment. *The lobule of the pneumogastric nerve* (*d*) is a sort of prominent tuft (flocculus), situated (*u*, *fig.* 276.) behind the pneumogastric nerve (8), and below the facial and auditory nerves (7).

The Internal Structure of the Cerebellum.

It is convenient to include under this head the description of the fourth ventricle, as well as that of the substance of the cerebellum.

The Fourth Ventricle.

Dissection. Divide the median lobe of the cerebellum vertically; make a vertical section of the pons along the median line; draw asunder the medulla oblongata from the cerebellum. By means of the first section the anterior wall of the fourth ventricle is exposed, and by the second its posterior wall; by drawing apart the medulla oblongata and cerebellum, the ventricle is reached by its inferior extremity, and its whole depth can be seen. It is important to examine the fourth ventricle in all its aspects.

The *fourth ventricle* (*v* to *y*, *fig.* 282.) is that rhomboidal cavity situated between the medulla oblongata and isthmus of the encephalon (*q n*), which forms its anterior wall, and the cerebellum (*w*), which constitutes its posterior wall. The old anatomists followed Galen in calling it the *ventricle of the cerebellum.* Tiedemann speaks of it as the *first ventricle*, because it is developed before the other ventricles, and is constant in all mammalia.

The fourth ventricle terminates in a point below, expands considerably in the middle, and is again contracted at its upper part, where it becomes continuous with the third ventricle.

We shall consider separately its anterior and posterior walls.

The *anterior* or *inferior wall* is formed by the posterior surface of the medulla oblongata (see *fig.* 271.) and that part of the upper surface of the isthmus of the encephalon which corresponds to the pons. In shape it resembles a lozenge or diamond, truncated at its upper point; the upper borders of the lozenge being represented by the superior peduncles of the cerebellum (*r* to *g*) and the lower by the restiform bodies (*e*): the posterior surface of the reinforcing fasciculi (*faisceaux innominés*) of the medulla oblongata constitutes this anterior wall, which is lined by a dense and easily separable membrane.

The *posterior* or *superior wall* represents a vaulted roof, which is formed above by the superior peduncles of the cerebellum (*r* to *g*) and the valve of Vieussens (*l*, *fig.* 271.; *l*, *fig.* 275.; *g w*, *fig.* 282.), lower down by the cerebellum (*w*), and below by a fibrous membrane, continuous with the neurilemma of the spinal cord.

Opposite the middle, *i. e.* the broadest, part of this posterior wall (see *fig.* 275.) are situated three mammillary projections — one median and two lateral: the first (*b*, the uvula) is the anterior segment of the median lobe of the cerebellum; the other two (the amygdalæ) are formed by the innermost laminæ of the lobule of the medulla oblongata (cut away at *f*). These latter are not bathed in the fluid of the ventricle, but are separated from it by the fibrous membrane lining that cavity.

The median mammillary projection (*b*), named by Malacarne and Chaussier the *laminated tubercle of the fourth ventricle*, resembles a moveable valve. It is attached to the cerebellum by two white pedicles, which pass outwards and backwards upon the lateral processes of the crucial eminence formed by the inferior vermis. Connected to its anterior extremity (the nodulus, *a*) are seen two broad folds (*semilunar folds*, *e*), which arise from it, one on each side, and become continuous with the roots of the corresponding sub-peduncular lobules or flocculi (*d*).

These folds, which are quite distinct from the valvulæ Tarini, are extremely thin and semi-transparent; their convex borders adhere to the back part of the fourth ventricle; their concave margins and their two surfaces are free.* The two semilunar folds and the intermediate projection, or the nodule, may be compared to the soft palate, the mammillary projection representing the uvula.†

* [These two folds constitute the posterior medullary velum of the cerebellum, the valve of Vieussens forming the anterior velum.]

† [The terms uvula and amygdalæ, or tonsils, have, as already noticed, been applied to

Opposite the *upper angle* of its rhomboidal cavity, the fourth ventricle (*v*, *fig.* 282.) becomes continuous with the third (*l*), through a canal, named *iter à tertio ad quartum ventriculum*, or the *aqueduct of Sylvius*, which, however, had been described by Galen: this aqueduct is formed beneath the tubercula quadrigemina (*f g*) and the valve of Vieussens (*g w*).

The *lateral angles* of the fourth ventricle are much elongated, and reach as far as opposite the inner extremity of the corpus dentatum of the cerebellum.

At the *inferior angle* (*y*) of the fourth ventricle is situated a fibrous layer, which constitutes its floor, and also an orifice of communication between the ventricle and the sub-arachnoid space.

The Fibrous Layers of the Fourth Ventricle.

Floor of the fourth ventricle. On carefully drawing the medulla oblongata away from the cerebellum, a fibrous layer is seen extending from one to the other, and forming as it were the floor of the fourth ventricle. This layer, which is continuous with the neurilemma of the medulla oblongata, consists of three very distinct parts; of a median portion, shaped like a triangular tongue, which passes horizontally backwards, and is applied to the anterior extremity of the inferior vermis, to which it adheres, and of two triangular lateral portions, which form the sides of the orifice of the fourth ventricle, and which were described by Tarin as the *valves of the base of the fourth ventricle.*

Besides this fibrous layer there is another on each side, situated behind the roots of the pneumogastric nerve: these layers adhere to those roots, and we shall, therefore, name them the *fibrous layers of the pneumogastric nerves;* they close the fourth ventricle upon the sides of the medulla oblongata, and when they are removed, the ventricle is quite open. They extend from the restiform bodies to the lobules of the pneumogastric nerves, and are prolonged upwards upon the auditory nerves.

The Inferior Orifice of the Fourth Ventricle.

If the medulla oblongata and cerebellum be drawn apart, there is seen, in the median line, between the inferior cerebellar arteries, a lozenge-shaped opening (at *y*, *fig.* 282.), bounded, in front, by the base of the calamus scriptorius; behind, by the anterior prolongation of the inferior vermiform process, which is covered by the median tongue of the fibrous layer; and upon the sides, in front, by the ragged edges of the lateral portions of the fibrous layer, and by the internal surfaces of the lobules of the medulla oblongata.

This opening was pointed out by M. Magendie as establishing a communication between the general ventricular cavity and the sub-arachnoid space. It has been asked, Is it a natural opening, or is it produced accidentally by the very means employed in its demonstration? The following are the arguments on both sides of the question:—

In opposition to the existence of an opening in this situation it is urged, that the margin of the orifice has none of the characters of that of a natural opening, the edges of which are generally smooth and rounded; but in this orifice they are lacerated, and there is almost always some membranous shreds at the point of the calamus scriptorius. If the median triangular tongue of the fibrous layer, which is applied to the inferior vermis, be detached, it is seen to be merely a flap of that membrane, the size of which exactly corresponds to that of the opening, so as to close it completely. This point may be rendered still more evident by tracing the membrane from before backwards, after having divided the pons and medulla oblongata.

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another series of three bodies which are arranged behind the nodule, the flocculi and the posterior vela, and consist of the laminated tubercle of the fourth ventricle, and of the inner portions of the lobes of the medulla oblongata (see p. 958.).]

Again: the fibrous layer, which forms the floor of the fourth ventricle, is entire in the dog and sheep; I have found it in the same condition five or six times in the human subject: and if it be objected that, in this case, there might have been an accidental obliteration of the opening, I could answer that there was no trace of disease, either in the cerebro-spinal axis, or in the membranes.

I may also mention that, in several cases of chronic hydrocephalus, several pounds of fluid were found in the ventricles, and none whatever in the sub-arachnoid space.

Lastly: in the brains of several infants, who had died with all the symptoms of acute ventricular hydrocephalus, I have found the lateral ventricles very large but empty; and in these cases it has occurred to me that the fibrous layer might have been perforated opposite the inferior angle of the fourth ventricle, and have thus allowed the fluid to escape, which, in the greater number of cases, is retained by this layer within the ventricular cavity.

Such are the facts which appear to me to militate against the idea of the existence of an opening in the floor of the fourth ventricle: but, on the other hand, if we consider that, in an immense majority of instances, whatever care may be taken in removing the brain from the cranium, we always find this opening both in the fœtus and in the adult; that in apoplectic effusions into the ventricles, we always find some bloody serum in the sub-arachnoid space; and that if a coloured fluid be injected into the ventricles of the cerebrum, or into the sub-arachnoid space around the cord, it will in either case pass freely from one into the other, we shall be led to conclude that there is a regular communication between the cavity of the ventricles and the sub-arachnoid space, and that the orifice just described is the channel of communication between them.*

The Choroid Plexuses of the Fourth Ventricle.

The *choroid plexuses of the fourth ventricle* are two in number; they commence one on each side, by a very slender extremity, upon the anterior surface of the sort of fibrous tongue which is attached to the inferior vermis; from this point they pass in a diverging course upwards, are then inclined outwards, turn round the sides of the median eminence of the fourth ventricle, pass horizontally outwards behind the restiform bodies, and then behind the fibrous layer of the corresponding pneumogastric nerve, where they become considerably enlarged, and at length terminate upon the sub-peduncular lobes.

The inner surface of the fourth ventricle is smooth, in consequence of being lined by a membrane resembling a serous membrane, which is much stronger over the posterior surface of the medulla oblongata than at any other point.

Sections of the Cerebellum.

On cutting through the cerebellum, it is found to be composed (see *figs.* 273, 274.) of two substances, an *external cortical* or *grey* substance, and a *central* or *medullary* substance, which is *white*; the grey substance is soft, and is almost always torn off with the membranes, however slightly the cerebellum may be altered by decomposition. The white substance is compact, and resists a tolerably firm pressure.†

Between the grey and white substances there is seen, upon a section of the cerebellum, a narrow yellowish band or streak, which depends on the existence of a layer of a yellow substance, of much greater firmness than the grey matter, and strongly adherent to the white substance. By laceration the grey matter is destroyed, and this yellow layer is exposed. There are, therefore, three substances in the cerebellum—the *grey*, the *yellow*, and the *white*. I would

* See note on the sub-arachnoid space (p. 920.).
† For an account of the minute structure of these substances, see note, p. 935.

compare the yellow layer of the cerebellum to the yellow folded membrane of the olivary bodies.*

A question here arises: What is the proportion between the grey and the white matter? The most superficial examination of the cerebellum will show that the grey matter predominates; and this can be clearly demonstrated by macerating the cerebellum for several days. The grey matter, which is more easily decomposed, becomes converted into a pulp, and the remaining nucleus of white substance scarcely represents a third, either of the weight or bulk of the cerebellum.

We shall now proceed to describe the appearance of vertical and horizontal sections of the cerebellum.

Vertical Sections.

Upon *longitudinal vertical sections* of the cerebellum, the grey and white substances present a very elegant arrangement, known by the picturesque name of the *arbor vitæ*; a title derived either from the importance which has been attached to this structure, or from its resemblance in figure to the foliage of the the tree so called. Upon a section, made through the median line, the *arbor vitæ of the middle lobe* (*w*, *fig.* 282.) is seen; and upon one made on either side, the *arbor vitæ of the lateral lobes.*

The *arbor vitæ of the median lobe* consists of a central nucleus of white substance, of a triangular form, from which two principal branches proceed; one inferior, which is distributed to the whole of the inferior vermis and the back part of the median lobe; the other superior, which passes into the whole of the superior vermis. These two branches subdivide into six others, which vary in direction, length, and thickness, and are themselves subdivided into still smaller branches, and these again into the smallest ramifications. A slight enlargement of the white substance is always observed opposite the points of division.

A very thin yellowish layer, and outside this a layer of grey matter, about a line in thickness, covers each of the ramifications of the white substance, and thus forms the lamellæ, laminæ, and segments of the median lobe.

This section enables us to prove the existence of the middle lobe of the cerebellum and the continuity of the superior and inferior vermis; it also shows the general form of the middle lobe, which is rotate, or wheel-shaped (the anterior extremity of the inferior vermis, *i. e.* the nodule, comes into contact with the valve of Vieussens); the number and arrangement of the segments, laminæ, and lamellæ of the cerebellum; and, lastly, the nature of the valve of Vieussens, which is nothing more than the uppermost subdivision of the central nucleus, and may be regarded as one half of a lamella of the cerebellum.

The arbor vitæ of the lateral lobes. A vertical section, from the middle peduncles of the cerebellum towards the circumference, displays the arbor vitæ of the lateral lobes.

In the centre of each lobe is seen a white central nucleus, from which fifteen or sixteen principal branches are given off to form the nuclei of a corresponding number of the segments. These branches are subdivided into secondary branches, and those into the ultimate ramifications. A yellowish layer covers each of these successive divisions, and upon that a grey layer, about a line in thickness, is accurately moulded.

Upon sections of this kind it is easily seen that the segments of the cerebellum are very unequal in size, in direction, and in their manner of division;

* Rolando (*Osservazioni sul' Cerveletto*, p. 187. 1823) appears to me to have been the first to establish the fact of the existence of three substances — the *medollare*, the *cinereo rossigna*, and the *cinerea esterna e corticale*.

that the superior segments are the smallest, the segments of the circumference the largest *, and the inferior segments of an intermediate size; that there is no vacant space between the segments, but that both laminæ and lamellæ occupy the intervals; and, lastly, that all of these segments curve forwards upon themselves, so as to form a series of horizontal wheels or circles, the plane of which is at right angles to that of the wheel-shaped mass of the middle lobe.

In the centre of the white nucleus of each half of the cerebellum is the *corpus rhomboideum*, or *corpus dentatum* †: these bodies are of an ovoid form; their yellowish investing layer is dense, and folded backwards and forwards upon itself, and exactly resembles that of the olivary bodies; and I have been accustomed to speak of these bodies as the olivary bodies of the cerebellum. Gall and Spurzheim regarded them as ganglions of reinforcement, and called them the *ganglions of the cerebellum*. Their shortest or vertical diameter is about one third of their long or horizontal diameter; in one case, where the latter was fifteen lines, the former was five lines: moreover, the size of the corpora dentata of the cerebellum varies in different subjects, and is in proportion to the size of the lateral lobes of that organ: they are, therefore, much less developed in the lower animals than in man.

The *peduncles of the cerebellum* are six in number, three on each side, namely a *superior*, a *middle*, and an *inferior*; they all originate, or, it may be said, terminate in the central nucleus.

The *superior peduncles of the cerebellum* are generally known as the *processus cerebelli ad testes*; they are seen (*r*, *fig.* 280.) in front of the superior vermiform process, and seem to pass up to the tubercula quadrigemina. We shall afterwards see that this is only apparent.

The *inferior peduncles* (*processus cerebelli ad medullam oblongatam*) are in fact the restiform bodies; they establish a direct and intimate communication between the cerebellum and the spinal cord.

Lastly: the *middle peduncles* (*m*, *fig.* 276.), which are anterior to the two preceding sets, occupy the fore part of the circumference of the cerebellum, and are continued into the pons Varolii without any line of demarcation. They are called also the *cerebellar peduncles* (*processus cerebelli ad pontem*), and the *crura* or legs of the medulla oblongata.

Horizontal Sections.

Horizontal sections of the cerebellum have been studied with very great care, and have been well figured by Vicq d'Azyr; they show that the dimensions of the central nucleus are much greater in the horizontal than in the vertical direction. ‡

Upon these sections, which should be made parallel to the upper surface of the cerebellum, is seen the relative disposition of the laminæ, which are sometimes parallel and sometimes oblique in reference to each other, and which either extend around the entire circumference of the organ, or terminate in tapering extremities and again commence, and pass from one segment to another.

Lastly: these horizontal sections show the continuity of the right and left lobes of the cerebellum by means of the middle lobe. In this middle lobe the lamellæ are more irregular than in the lateral lobes; they intersect each

* The segment of the circumference, which is the largest of all, immediately divides into two smaller segments; it has been incorrectly stated that there is a horizontal fissure along the circumference of the cerebellum, extending from one of the middle peduncles to the other.

† In order to divide the corpus dentatum, the section must be made opposite the corresponding inferior peduncle of the cerebellum. I would recommend that one section be made to extend through the corpus dentatum of the cerebellum, and also through the olivary body, so that some idea may be formed of the analogy between these two parts.

‡ In each lobe of the cerebellum there is a *medullary centre*, that is, a spot in which the section of the white substance is larger than at other points.

other at various angles, and become again united into new combinations, so that several anatomists have admitted the existence of a true decussation in this middle portion of the cerebellum.

The middle lobe also has its medullary centre, which connects the lateral medullary centre in such a manner, that, by a successful section, a sort of cerebellar centrum ovale is obtained, analogous to the centrum ovale of Vieussens in the cerebrum.

Examination of the Cerebellum by means of a Stream of Water, and Dissection of the hardened Cerebellum.

A stream of water directed upon vertical sections of the cerebellum decomposes the white nucleus of each lateral lobe into a great number of extremely thin leaves, which constitute the different laminæ or lamellæ of the cerebellum. All these laminæ and lamellæ terminate in the central nucleus of the corresponding lobe. Each lamella is fan-shaped, its adherent border being very narrow, concave, and applied to the central nucleus, with which it is evidently continuous, whilst its convex margin corresponds to the surface of the cerebellum. The arrangement of these lamellæ is very beautiful and curious; some of them ascend to form the segments, laminæ, and lamellæ of the upper surface of the cerebellum; others descend to form the corresponding parts of the lower surface, and the intermediate ones pass horizontally to the circumference, and are disposed in a similar manner. Opposite each point of subdivision there seems to be an enlargement of the white substance, but this depends not upon an actual increase of that substance, but upon the divergence of the lamellæ.

The structure of the cerebellum therefore, considered generally, is laminated. From the central white nucleus proceed innumerable laminæ, which though in juxtaposition, are never blended together, and which form groups, that are themselves subdivided again and again, like the branches of a tree, the ultimate lamella always containing at least two leaflets. Can anatomy teach us any thing beyond this laminated arrangement? In each lamella certain radiated striæ are seen; and it may be asked, whether these prove the existence of a linear or fibrous structure? It is certainly true that the lamellæ may be divided in the direction of these striæ, but it is far from being evident that they consist of linear fibres.

In the central nucleus, the laminæ, being more firmly pressed together, are separated by the stream of water with greater difficulty than the laminæ near the surface: the corpora dentata of the cerebellum are peculiarly firm. The stream of water insinuates itself into these bodies opposite their internal extremity, which appears to be naturally open, and divides them into two halves, a superior and an inferior. It is then seen that the dentated appearance of their section results from the reduplication of the dense yellowish layer in which they are inclosed; also that the white substance penetrates into the interior of these bodies at their internal surface, accompanied by a great number of vessels; and that this white substance is arranged in lamellæ, which terminate at three different points of the yellowish layer, so that each of the corpora dentata resembles a small cerebellum.

Examination of the hardened cerebellum. The examination of the cerebellum, when hardened by alcohol, or by boiling in oil, or salt and water, or by maceration in a solution of salt and bichloride of mercury, of the strength recommended by Rolando, confirms all the results which have been obtained by the preceding method of investigation.

These modes of preparation, moreover, enable us to examine more completely than in any other way the relations of the central nuclei of the lobes to the peduncles of the cerebellum. It is seen most distinctly that these peduncles

(*m n*, *fig.* 273.; *n r*, *fig.* 274.) emerge from or terminate in the central nuclei (*p p*), but it is very difficult to ascertain their precise arrangement within the nuclei. All that we know is the fact, that as soon as they emerge from the central nuclei they assume a fasciculated character, and that all the lamellæ and laminæ of the cerebellum seem to terminate in the fibres of the middle peduncles.

General View of the Cerebellum.

From the preceding statements we may draw the following conclusions:— The cerebellum consists of two lateral lobes and a middle lobe; the lobes are formed by a considerable number of segments, which are subdivided into smaller segments, and these into laminæ and lamellæ; each lobe contains a central medullary nucleus upon which all the segments rest, and which constitutes the termination or the origin of the several peduncles; the substance of these peduncles is fibrous or fasciculated, and that of the central nucleus has a similar character, but not so well marked; the medullary substance of each segment is formed by laminæ applied to each other, but not actually continuous; each of these laminæ is fan-shaped, and those which constitute the central nucleus of each segment become separated from each other to form the secondary segments, the laminæ and the lamellæ; the ultimate lamellæ of the cerebellum consist of two leaflets of white matter covered externally by a very thin yellowish layer, which is itself covered by a rather thick layer of grey matter*; the corpora dentata or olivary bodies of the cerebellum consist of fibres or laminæ of medullary substance, which are spread out so as to terminate at different points upon the inner surface of the dense yellow membranous layer which constitutes their external investment.

A very ingenious explanation of the structure of the cerebellum has been proposed by Gall, and is now rather generally adopted.

The opposite directions of the inferior and middle peduncles of the cerebellum suggested to him the idea of *diverging and converging fasciculi*, and to this he has added his theory regarding the ganglia, which he considered as apparatuses of reinforcement, that is to say, as points of origin for new fasciculi.

According to Gall, then, the inferior peduncles of the cerebellum or the restiform bodies (*n*, *fig.* 274.), which he calls the *primitive fasciculi of the cerebellum*, are the roots, or fasciculi of origin of the cerebellum. After they have penetrated a few lines into the substance of the organ, they meet with and join the corpus dentatum, which Gall regards as a *true ganglion*, or *apparatus of origin and reinforcement for a great part of the nervous mass of the cerebellum.* According to him, a principal nervous fasciculus corresponds to each of the folds of the corpus dentatum, from which ganglion arise all those prolongations of medullary substance, which together with the grey matter upon them constitute the middle and lateral lobes of the cerebellum.

Besides the preceding fasciculi, which are named by Gall the *diverging fasciculi*, and are said by him to constitute the *formative system* of fibres, there are certain *converging fasciculi* which constitute the *uniting system of fibres*, or the *commissures of the cerebellum.* These are supposed to have no direct connection, either with the primitive fasciculi or the corpus dentatum, but to emanate from the grey matter upon the surface of the cerebellum, and to pass in different directions (*p q*, *fig.* 273.) between the diverging fasciculi, so as to enter into and constitute the middle peduncles of the cerebellum (*m*) and the

* [The white substance of the laminæ is said to consist of two sets of fibres — one coming from the central mass, and passing up the centre of the laminæ, and the other set lying upon the first, and passing from one lamina to another.]

pons Varolii, which Gall regarded as forming together the commissure of the cerebellum.

The superior peduncles of the cerebellum (*r'*, *fig.* 274.) he considered as fasciculi of communication between the middle median lobe of the cerebellum and the corpora quadrigemina, and the valve of Vieussens as the commissure of these peduncles.

We can only regard Gall's view concerning the structure of the cerebellum as an ingenious speculation. Why should the inferior fasciculi be the roots or primitive bundles of the cerebellum rather than the superior? Who has seen the reinforcement of these primitive fasciculi in the corpus dentatum? Why should the corpus dentatum be regarded as a ganglion? Whence is this distinction between converging and diverging fasciculi?* and, finally, Why are figure and metaphor employed in reference to strictly anatomical questions?

Another theory regarding the structure of the cerebellum has been offered by Rolando, who by combining the results derived from an examination of the human cerebellum, when hardened in a strong saline solution, with those furnished by the anatomy of the brain of the shark, and those obtained by studying the developement of the brain of the fowl, was led to regard the human cerebellum as formed by the folding and refolding upon themselves of the parietes of a large bladder or vesicle, so as to give rise to innumerable laminæ.†

The facts we have already stated sufficiently refute this hypothesis. It is quite certain that the cerebellum is formed by the union of one middle and two lateral lobes: the lobes themselves are composed of a considerable number of segments, which are subdivided into smaller segments, laminæ, and lamellæ. The general structure of the cerebellum is laminated, and these laminæ are striated; each lamella contains two leaflets of white substance covered with grey matter. The cerebellum is connected with the medulla oblongata by the inferior peduncles, and with the brain by the superior peduncles; the middle peduncles and the transverse fibres of the pons establish an intimate connection between the two lobes of the cerebellum.‡

Developement of the Cerebellum.

The cerebellum does not appear until some time after the spinal cord: it consists at first of two laminæ and plates prolonged from the cord, which approach each other towards the median line; these are the inferior peduncles of the cerebellum or the restiform bodies. The human cerebellum in this condition has a close resemblance to the same organ in fishes and reptiles. At the fourth month, the cerebellum forms a sort of uniform girdle, four lines in width, around the tubercula quadrigemina and the medulla oblongata; the pons Varolii is already visible; there is a rudiment of the corpus dentatum, and the surface of the cerebellum is entirely devoid of fissures. At the fifth month there are four transverse fissures: a vertical section of the cerebellum presents five branches; but there are as yet neither laminæ nor lamellæ, nor

* "These converging fibres," says Tiedemann (French translation by Jourdan, p. 169.) "are merely chimerical; for the pons Varolii, and the medullary fibres of which it consists are found in the fœtus at the fourth month, that is, at a period when there are no laminæ, nor lamellæ, nor even any leaflets covered with grey matter. Gall, therefore, assumes these converging fibres to originate from parts which do not appear until after those fibres themselves." The refutation of Tiedemann appears to me to be itself founded on an assumption, for there is no proof that the grey matter is formed after the white.

† Osservazioni sul' Cerveletto, p. 187. In the shark the cerebellum consists of a grey and a white layer united together and folded a great number of times upon themselves.

‡ It is not yet ascertained whether the lateral halves of the cerebellum act upon the same or opposite sides of the body; some cases, in which atrophy of one hemisphere of the cerebrum co-existed with atrophy of the opposite hemisphere of the cerebellum, would appear to show that the action of the latter is not crossed. The laminated structure of the cerebellum and its twofold composition suggested to Rolando the idea of comparing it to a voltaic pile, or electromotive apparatus.

is there any distinction between the middle and lateral parts. At the sixth month the cerebellum is divided by the posterior notch, the different orders of fissures are visible, and the corpus dentatum has acquired considerable size. During the last three months of intra-uterine existence, the lateral lobes generally acquire that predominance over the middle lobe which is found to hold after birth.

As the developement of the spinal cord precedes that of the cerebellum, and as the cerebellum appears to be formed by a prolongation of the posterior fasciculi of the cord, does it follow that that organ is a production or an expansion of the cord? Certainly not; all that we can conclude is, that they are developed in succession.

Reil and Tiedemann have advanced the opinion, that the cerebellum is secreted by the pia mater, and that the grey matter is deposited the last; but this is only an assertion without demonstration.

The cortical substance is formed at the same time as the medullary, and neither of them can be considered as the product of the other.

Comparative Anatomy of the Cerebellum.

In fishes the cerebellum is generally small, but in the ray and shark it is large, subdivided into convolutions, and prolonged above the optic lobes in front, and above the lobe of the eighth pair of nerves behind. In the silures, as Weber has observed, the cerebellum is relatively as large as the human cerebrum; for it covers the posterior half of the cerebral lobes, as the cerebrum in man covers the cerebellum. In all fishes the cerebellum contains a considerable cavity. In some of this class of animals it is subdivided into segments, laminæ, and lamellæ.*

Reptiles. There is no cerebellum in the *bàtrachia* (as in the frog, toad), and ophidia (serpents); most anatomists, however, admit its existence in a rudimentary state. It is very small, and shaped like a roof, or vaulted, in the chelonians (tortoise); it is very long in the saurians (lizard, crocodile).

Birds. The cerebellum is very large, and represents an ellipsoid, having its long diameter directed vertically. It is deeply and regularly traversed by horizontal fissures, which are curved downwards on the upper half, and upwards on the lower half of the organ. They all terminate opposite two small tubercles or appendages situated one at each extremity of the transverse diameter. Upon a section of the cerebellum of birds is seen an arbor vitæ, composed of white substance covered with grey matter.

Mammalia. In the three classes already examined, the cerebellum has merely a middle lobe: in all mammalia there are also *lateral lobes.* They are at first small, like appendages as in the rodentia, in which the cerebellum differs but little from that of birds; they gradually increase in size as we proceed upwards in the scale, until they reach their highest state of perfection in man, the developement of whose cerebrum and cerebellum exceeds that of the same parts in all the lower animals. In mammalia the size of the lateral lobes of the cerebellum is directly proportioned to that of the olivary bodies, the existence of which in this class Vicq d'Azyr has erroneously denied.

* [It is divided into segments by deep transverse furrows in some cartilaginous fishes.]

THE CEREBRUM, OR BRAIN PROPER.

Definition — situation — size and weight — general form. — The superior or convex surface.—The inferior surface or base—its median region, containing the interpeduncular space, the corpora albicantia, the optic tracts and commissure, the tuber cinereum, infundibulum, and pituitary body, the anterior part of the floor of the third ventricle, the reflected part of the corpus callosum, the anterior part of the longitudinal fissure, the posterior part of the longitudinal fissure, the posterior extremity of the corpus callosum and median portion of the transverse fissure, and the transverse fissure. — The lateral regions, including the fissure of Sylvius and the lobes of the brain. — The convolutions and anfractuosities of the brain, upon its inner surface, its base, and its convex surface — uses of the convolutions and anfractuosities. — The internal structure of the brain — examination by sections — horizontal sections showing the corpus callosum, the septum lucidum, the fornix and corpus fimbriatum, the velum interpositum, the middle or third ventricle, the aqueduct of Sylvius, the pineal gland, the lateral ventricles, their superior and inferior portions, the choroid plexus, and the lining membrane and the fluid of the ventricles — median vertical section — transverse vertical sections — section of Willis. — General remarks on this method of examining the brain. — Methods of Varolius, Vieussens, and Gall. — Gall and Spurzheim's views on the structure of the brain. — General idea of the brain. — Developement. — Comparative anatomy.

The *cerebrum* or *brain*, strictly so called, is that portion of the encephalon which occupies the whole of the cavity of the cranium, except the inferior occipital fossæ. It forms as it were the crown or summit of the spinal axis, surmounting it (*cerebrum superius*), and at the same time lying in front of (*cerebrum anterius*) the spinal cord, as the origin and termination of which it has been alternately regarded. By the pons Varolii and the anterior or cerebral peduncles it is intimately connected with the cerebellum and the spinal cord. The tentorium cerebelli completes the cavity in which it is inclosed, and separates it from the cerebellum, which is situated below its posterior lobes. The cranium, the dura mater, the arachnoid, and the pia mater form a fourfold investment for it.

Size and Weight of the Cerebrum.

The great *size* of the cerebrum is undoubtedly one of the most characteristic points in the structure of man: in several animals, the entire encephalon is relatively as large, and even larger (*ex.* the canary bird, the sapajou, the dolphin); but in reference to the size of the brain properly so called, *i. e.* of the cerebral hemispheres, even the most favoured animals are much inferior to man.*

In the adult, the weight of the cerebrum, detached from the cerebellum and the pons by a section through its peduncles, varies from two to three pounds.† I believe it to be impossible to construct a table of the comparative size and weight of the brain and of the body. Is it not evident, indeed, that one

* The weight of the cerebrum of the horse and the ox is scarcely half that of the human cerebrum.

† [From the statements given by Tiedemann (*Hirn des Negers, &c.* p. 6. Heidelb. 1837) it appears that the prevalent weight of the brain (entire encephalon) in the adult male is about from 44 to 48 oz. troy; in the adult female, from 40 to 44 oz. The results deducible from Dr. Sims's tables do not materially differ from the above.

In thirty-nine males, varying in age from 22 to 80, Tiedemann found the minimum weight of the brain 38 oz. 20 gr., the maximum $59\frac{1}{2}$ oz.

In eleven females, from 20 to 80 years of age, the minimum was 32 oz. 5 drs. 50 grs., the maximum 46 oz. 2 drs.

The extremes, according to Dr. Sims's observations, were, in about seventy males from 20 to 91 years, lowest, 33 oz. 80 grs.; highest, 54 oz. 6 drs. troy weight. In ninety females, between the ages of 20 and 89, the lowest was 27 oz. 80 gr., the highest 51 oz. 6 drs.]

element in the comparison, namely, the weight of the body, is subject to great variety? Haller has recorded the results of all the calculations which have been made upon this subject, and the diversity of those results is the best comment that can be made upon this mode of comparison.

These remarks do not apply to the relative proportions between the cerebrum and cerebellum. According to my own observations, the weight of the cerebellum is from the twelfth to the eighth part of that of the cerebrum.*

It is important to obtain some approximation to the relative size of the brain in different individuals in the two sexes, and at different ages.

It results from a great number of facts, that the size of the brain is independent of the stature of the individual; that the size of the brain is also independent of sex, although since the time of Aristotle it has been the custom to repeat that the female brain is smaller than that of the male; that in the fœtus and the infant the cerebellum is relatively much larger than in the adult; and that in old age the brain is often atrophied like other organs, and then does not completely fill the cranial cavity.

Can the size of the brain be increased by exercise, and diminished by inaction? It cannot be doubted that the brain must, in this respect, obey the laws which regulate all other organs; but the bony parietes of the cranium must offer great obstruction to its developement; indeed, examples have been recorded of compression of the brain, and even of death produced by hypertrophy of this organ.

If it be true that the power of an organ depends upon its size, it follows that the size of the brain, and consequently the capacity of the cranium, must have a tolerably close relation to the developement of the cerebral functions; but the activity of these functions is connected with so many circumstances, besides the size and quantity of brain, that any estimate of the intellectual powers founded exclusively upon these data is very often faulty and inexact.†

The specific gravity of the brain as compared with that of water is, according to Muschenbroek, as 1030 to 1000. It would be interesting to determine whether its specific gravity varies according to age and in disease, and also whether it differs in different animals. According to Soemmerring, the specific gravity of the brain in old persons is less than in those of middle age.

General Form of the Cerebrum.

The form of the cerebrum corresponds exactly to that of the cranial cavity, which is, as it were, moulded on it; it is therefore variable like that of the cavity itself, which, during early infancy, is capable of assuming all sorts of shapes from the application of external pressure.

If the entire cranial cavity, excepting the posterior occipital fossæ, be filled with plaster of Paris, an exact representation will be obtained of the general form of the brain which had been removed. The cerebrum, therefore, is like the cranium of an ovoid figure, having its large end turned backwards, and its small one forwards. It is divided on its under surface into *lobes*, which occupy the different compartments in the base of the cranium. The entire

* In three young subjects I found as follows: —

	lb.	oz.		oz.
Cerebrum - -	2	2	Cerebellum - -	4½
— - -	2	8½	— - -	3½
— - -	2	5	— - -	5

† Persons endowed with strong memories have always appeared to me to have large brains; and the part which the memory performs in the exercise of mind is of such a nature, that we cannot be surprised if the persons alluded to are frequently men of superior intellect. I have known many persons, having heads of considerable size, who had merely a good memory, but none of the characteristics of genius. Those in whom the brain is large seem to me to resist the power of disease better than such as have small brains.

surface is marked by deep tortuous furrows (see *figs.* 276. 282.), called *anfractuosities*, which occasion an appearance like that of the convolutions of the small intestines, and hence the term *convolutions* is applied to the eminences resembling folds, by which the anfractuosities are bounded.

The Superior or Convex Surface of the Brain.

A *median vertical fissure* running from before backwards, called the *longitudinal fissure*, divides the cerebrum into two exactly similar lateral halves, which are improperly called *cerebral hemispheres*, for each of them resembles the fourth part of an ovoid; but would be more correctly designated the right and left brain, as was done by Galen.* The longitudinal fissure divides the cerebrum in its whole depth, both in front and behind (*x y*, *fig.* 277.; also *fig.* 282.); but in the middle it is interrupted by the *corpus callosum* (*d d*). There are two brains, as there are two spinal cords and two cerebella.†

The cerebrum is therefore *symmetrical*, but it is less completely so than the spinal cord; I should even say, that a decided disproportion is very commonly observed between the right and left hemispheres. It does not appear that this want of symmetry exerts that influence upon the intellectual faculties which was imagined by the ingenious Bichat, whose own unsymmetrical brain was in direct contradiction to his doctrine. It is nevertheless possible that a want of symmetry, when carried to a certain point, may affect the intellect; in the brains of several idiots their want of symmetry has been very remarkable. I have seen the longitudinal fissure of the brain deviate to the right or left side, at an angle of from 15° to 20° from its usual direction.

Each cerebral hemisphere presents three surfaces for our consideration: —

An *internal surface* (*fig.* 282.), which is flat, vertical, and separated from that of the opposite hemisphere by the falx cerebri; but as the falx does not extend so low as the corpus callosum, it follows that the two hemispheres are in contact below, the pia mater, however, intervening between them. In those rare cases of absence of the falx cerebri, the corresponding faces of the two hemispheres are in contact with each other throughout their whole extent. I have seen one case in which the falx was imperfect, and the two hemispheres were united.

An *external surface*, which is convex, and resembles the surface of the fourth part of an ovoid, having its great end directed backwards; it corresponds to the concavity formed by the frontal, parietal, and occipital bones.

An *inferior surface*, which forms part of the base of the brain in general, and will be next described.

The Inferior Surface or the Base of the Brain.

The *base of the brain* (*fig.* 276.), admirably described and correctly figured by Soemmerring in a special treatise upon the subject *, presents a great number of objects for our consideration. In order to obtain a perfect knowledge of it, it is advisable to examine it whilst the brain is still inclosed in its membranes, and placed in the skull cap, with its base uppermost; and also upon a brain from which the membranes have been removed, and which is placed in the same position but on a flat surface. In the former case, the parts forming the base of the brain are pressed together, and may be studied as a whole; and in the latter, they are separated and may be examined in detail.

It is at its base that the brain is connected with the other parts of the cerebro-

* Chaussier applies the term *lobe* to the hemispheres, reserving that of *lobule* for the secondary divisions.

† Galen inquires why there should be two brains; and replies, that it is to insure a more perfect performance of the cerebral functions. I have seen several hemiplegic individuals in whom the whole of one hemisphere was atrophied, but who, notwithstanding, possessed ordinary intellectual faculties.

‡ De basi Encephali (*Ludwig*, *Scriptores Neurologici*, t. ii.).

spinal axis, by means of the right and left *peduncles* (*f f*), which may be regarded as the roots of the two hemispheres.

Fig. 276.

The median region. In the median line, opposite the centre of the base of the brain, and in front of the pons Varolii (*d*), is situated an excavation, which may be called the *median excavation of the base of the brain.* This excavation has already been alluded to in the description of the arachnoid membrane and the sub-arachnoid fluid, with which this excavation is filled: it is formed by the brain being curved upon itself, and is partially effaced when that organ is placed with its base uppermost upon a flat surface: this excavation is of a pyramidal form, the apex being directed upwards, and the base downwards. The borders of the excavation form a hexagon, and contain the arterial hexagon of the base of the cranium, named the *circle of Willis.* The posterior borders of the hexagon are formed by the peduncles of the brain, the lateral borders by the inner part of the posterior lobes [*c*, middle lobes] * of the cerebrum, and the anterior borders by the inner and back part of the anterior lobes (*a*) of the cerebrum.

From the six angles of this hexagon, six furrows proceed in different directions; from the anterior angle, the fissure which separates the anterior lobes, or the great longitudinal fissure (*x*) of the brain; from the two anterior lateral angles, *the corresponding fissures of Sylvius* (*y y*); from the posterior lateral angles, the two extremities (external to *f f*) of the *great cerebral fissure*, or *great transverse fissure* of the brain; and from the posterior angle (*r*), which

* *I.e.* of the *middle* lobes of anatomists generally (*c*, *fig.* 276.), which, it must be remembered, the author, agreeing with Soemmerring, does not regard as distinct from the posterior lobes (*b*), and to which, therefore, he does not apply the term "middle lobes." This term is, however, for the most part added [between brackets] in the translation, as it is generally used in anatomical descriptions in this country.]

corresponds to the interval between the cerebral peduncles, the longitudinal groove (*d*) upon the pons Varolii.

In the area of this median excavation are seen, the *interpeduncular space* (above *r*), the *mammillary tubercles* (*z*, *corpora mammillaria vel albicantia*), the *optic tracts* (*s*) and *optic commissure* (*t*), the *posterior part of the floor of the third ventricle* or the *tuber cinereum* (*v*), the *infundibulum* (*i*), and the *pituitary body*.*

In front of the median excavation are situated, counting from behind forwards, the *anterior part of the floor of the third ventricle* (*lamina cinerea*; *m*, *fig.* 282.), the *under or reflected portion of the corpus callosum* (*e*), and the *inferior part of the longitudinal fissure of the cerebrum* (*x*, *fig.* 276.).

Behind the median excavation is the pons Varolii, and, behind that, the middle part (*r*, *fig.* 282.) of the *great transverse fissure*, by which the pia mater enters (above *p*) the third ventricle, the thick *posterior extremity* (*f*) *of the corpus callosum*, and the *posterior part of the longitudinal fissure of the cerebrum.*

The lateral regions of the base of the brain. Upon each of these regions are seen the *inferior surface of the corresponding anterior lobe* (*a*) *of the cerebrum*, the *fissure of Sylvius* (*y*), by which this lobe is separated from the posterior lobe [middle lobe of others, *c*], and the inferior *surface of the posterior* lobe itself (*c b*). There is no distinct middle lobe.†

I shall now describe successively and in detail the several parts just enumerated, with the exception of the cerebral peduncles and the pons Varolii, which have already been noticed as constituent parts of the isthmus of the encephalon.

The Median Region of the Base of the Brain.

The Interpeduncular Space.

This space (above *r*) is of a grey colour, it is perforated by numerous openings for the transmission of vessels, and is termed the middle or posterior perforated spot (*locus perforatus*); it contains the origin of the third pair of nerves (3). A longitudinal groove and two fasciculi, separated from the corresponding cerebral peduncle by a blackish line, are seen in this spot. These interpeduncular fasciculi are formed by a prolongation of the fasciculi of reinforcement (*faisceaux innominés*) of the medulla oblongata.

The Corpora Albicantia.

The *mammillary tubercles* (*corpora albicantia vel mammillaria*, *z*) are two small pisiform or rather hemispherical globules, composed externally of white, and internally of grey substance, situated behind the tuber cinereum, which is accurately adapted to their anterior surface, also behind the infundibulum, and between the peduncles of the brain. They are separated from each other by a deep fissure, excepting at their highest part, where they are connected by means of a thin layer of grey matter, which is very easily torn; they correspond (*z*, *fig.* 282.) to the floor of the third ventricle (*l*).

It will be hereafter seen, that the white covering of these small bodies is formed by the termination of the anterior pillars of the fornix, and hence the name given them by Casserius, the bulbs of the anterior pillars of the fornix (*bulbi priorum crurum fornicis*), a name which should be preserved. The two corpora albicantia are generally of equal size. In several cases of atrophy of one of the hemispheres of the cerebrum, I have found the corresponding mammillary tubercles also atrophied.

We are completely ignorant of the function of these bodies.

* [To avoid confusion in the drawing, the pituitary body is not represented in *fig.* 276.; its point of attachment is to the infundibulum (*i*).]

† See note, p. 971.

In man and the carnivora only are there two mammillary tubercles, and in all the other vertebrata there is but one. They attain their highest state of developement in fishes, if, as stated by Vicq d'Azyr, they are represented by the two larger lobes, which occupy a corresponding situation in that class of animals. During the early periods of fœtal life they are blended together into one tolerably large mass, and do not become distinct from each other until about the seventh month.

The Optic Tracts and Commissure.

At the point where the peduncles of the cerebrum pass into the brain, each of them is surrounded by a white band, named the *optic tract, or tract of the optic nerve.* Each of those tracts commences, behind, at an eminence called the *corpus geniculatum externum* (*j, fig.* 271.), which will be seen hereafter to be an appendage of that part of the brain named the *optic thalamus.* The corpus geniculatum internum (*i, fig.* 271, 272.) of authors is merely a tubercle inserted into the bend or knee formed by the corpus geniculatum externum. The optic tract (2, *fig.* 272.) then is the continuation of the corpus geniculatum externum, from which it is distinguished by its whiteness, which contrasts strongly with the grey colour of that body: it is at first broad, flattened, and thin, and is applied to the corresponding cerebral peduncle, being distinguished from the peduncle only by the direction of its fibres. It then turns horizontally around the peduncle, is detached from it, and at the same time becomes narrower and thicker; having reached the front of the peduncle it changes its direction, passes forwards and inwards (*s, fig.* 276.), and is united with its fellow of the opposite side, to form the *commissure* or *chiasma* (*t*) of the optic nerves (2). The optic tracts may be regarded as forming a *commissure to the two optic thalami.*

These tracts and the cerebral peduncles of the two sides inclose a lozenge-shaped interval, in which are situated the posterior perforated spot, the corpora albicantia, the tuber cinereum, the infundibulum, and the pituitary body.

The Tuber Cinereum, the Infundibulum, and the Pituitary Body.

The term *tuber cinereum* (*v*) has been applied by Soemmerring to the soft grey mass which occupies the triangular interval between the corpora albicantia and the optic tracts. It is also called *the floor of the third ventricle,* because it closes that cavity behind and below, and the *base of the infundibulum,* because that part is attached to it.

The *infundibulum* (la tige pituitaire, *Lieutaud;* la tige sus-sphenoidale, *Chauss.*) is a reddish process (*i*), about two lines in length, directed very obliquely downwards and forwards (*i, fig.* 282.), and applied to the lower surface of the tuber cinereum: it is broad at its upper extremity, but soon diminishes in diameter, and descends to be inserted into and become continuous with the pituitary body.

Is the infundibulum hollow, or is it a solid stem? The term infundibulum or funnel, applied to this part by the older anatomists, and the following synonymes, *pelvis colatoria, scyphus, aquæ ductus, encephali sentina,* afford ample evidence of both their anatomical and physiological views regarding it. Galen and Vesalius, who are so often at variance, are perfectly agreed upon this subject, and describe the infundibulum with a minute exactness; but since the communication supposed by Galen to exist between the nasal fossæ and the brain by means of passages through the ethmoid and sphenoid bones, and the equally hypothetical communication admitted by Vesalius, are known to have no existence, anatomists have rejected the notion of the passage of a fluid from the brain in this direction, and they no longer regard the infundibulum as a funnel intended for its transmission. Haller has collected in some learned notes the contradictory opinions of his predecessors, but has left the question

still in doubt. Nor has Soemmerring himself, after a long detail of investigation into the subject, arrived at a more satisfactory result.*

A careful examination of the infundibulum has convinced me that there is, at least in a certain number of cases, a funnel-shaped canal, precisely similar to that which was described and figured by Vesalius: it is wide above, where it communicates with the third ventricle, and narrow below, where it reaches the pituitary body, a body which the ancients had not named, but which Vesalius called *glans pituitam excipiens*. In order to demonstrate this canal, the optic tract must be turned backwards, and the semi-transparent corneous lamina, which forms the anterior part of the floor of the third ventricle, must be divided; behind a white band, which is quite distinct from the anterior commissure of the brain, there is then seen a circular opening sufficiently wide to admit the blunt end of a large probe, which may accordingly be passed through the entire length of the infundibulum as far as the pituitary body. Again: by cutting the infundibulum across, and then blowing upon it through a blow-pipe, or letting some drops of water fall upon it, a perfectly circular opening may be demonstrated, which cannot be produced by the means employed in the demonstration.

Lastly: we may adopt the method of Vesalius, who filled the third ventricle with a coloured liquid, which soon reached the pituitary body. The same experiment succeeds still better with mercury. Nevertheless, I ought to state, that in two cases of dropsy of the third ventricle, no fluid escaped from the infundibulum when it was cut across.

It is easy to show the structure of the infundibulum. A fibrous and vascular membrane, continuous with the pia mater, forms its external covering, and this is lined by a thin layer of grey matter, which is continuous with that of the floor of the third ventricle. This grey matter forms a solid cord when the infundibulum is not tubular.

The *pituitary body*† is a small body, weighing from five to ten grains, which occupies the sella turcica, or supra-sphenoidal fossa (appendice sus-sphenoidale du cerveau, *Chauss.*; hypophysis, *Soemm.*). The better to appreciate its size, it is convenient to break down, with a chisel, the quadrilateral plate which forms the posterior wall of the sella turcica or pituitary fossa, and which is itself hollowed in front, so as to increase the antero-posterior diameter of that cavity.*

Inclosed in the sella turcica, the pituitary body is kept in that situation on each side by the fold of the dura mater, which constitutes the cavernous sinus, and above by a portion of the same membrane, which forms a circular orifice around the infundibulum.

The coronary sinus, which is situated between the pituitary body and the margin of the sella turcica in front and behind, and the cavernous sinuses on each side, form a vascular circle around this body, but it is not bathed in the blood as stated by some.

The upper surface of the pituitary body is slightly excavated, still it is not unfrequently convex, so as to project more or less above the level of its fossa.

On removing the pituitary body, it is seen to be formed of two distinct lobes, of which the anterior is the larger, whilst the posterior occupies the small cavity in the quadrilateral plate. These two lobes have been very well described by the brothers Wenzel; they are not of the same colour, the pos-

* Ludwig, Script. Neurolog.; Soemmerring, De basi Encephali, p. 41. "Quibus omnibus *absque partium studio* rite mecum perpensis, non potui non complecti illorum virorum sententiam, qui infundibulum, si non perfecte solidum, certe *non adeo conspicuo*, uti veteres opinati sunt, *canali perforatum* esse, censuerunt. Hunter and Cruickshank say that the infundibulum is sometimes solid, and sometimes tubular.

† Not shown in *figs* 276. 282.

‡ In order to obtain a perfect examination of the pituitary body and infundibulum, it is well to sacrifice a brain and the base of the cranium, and to remove, by a circular incision, the body of the sphenoid bone, together with the corresponding part of the base of the brain.

terior lobe being greyish white, like the grey substance of the brain, and the anterior yellowish grey.

If the anterior lobe be pressed between the fingers, a yellowish white pulp escapes from it, very nearly resembling mixed plaster of Paris. An antero-posterior section of the pituitary body shows also that the two lobes are perfectly distinct, being separated by a fibrous layer. They are provided with a great number of small vessels. It has been stated, but not proved, that the infundibulum contains two canals, one for the anterior, and the other for the posterior lobe. It is extremely rare to find any hard concretions in the pituitary body like those met with in the pineal gland.

It is perhaps not uninteresting to remark that the pituitary body is most highly developed in fishes, in which animals it forms a true lobe; and that it is proportionally more developed in mammalia, birds, and reptiles, than in the human subject. It is hollow in all the lower animals.

It is larger at the fourth, fifth, and sixth months of fœtal life than after birth, and contains a cavity which communicates with the third or middle ventricle. I once found a considerable cavity in the pituitary body of an adult.

The *functions* of the pituitary body are enveloped in the greatest obscurity. Its constancy in all vertebrated animals and its great vascularity are sufficient evidence of its importance. It certainly communicates with the third ventricle, but for what purpose? Does it pour a peculiar fluid into that cavity, or does it absorb a portion of the ventricular fluid? Whatever may be the use of the communication just alluded to, the pituitary body does not communicate directly with the venous sinuses around it: it is not a lymphatic gland as maintained by Monro; nor is it a nervous ganglion of the great sympathetic, as some have recently conjectured, because they fancied they saw some very fine nervous filaments anastomosing upon it. The branches of the fifth and sixth nerves, which Litre and Lieutaud say they have seen penetrating this body, have not been demonstrated.

The Anterior Part of the Floor of the Third Ventricle.

The *anterior part* (*m*, *fig.* 282.) *of the floor of the third ventricle*, which cannot be well seen until the commissure of the optic nerves is turned backwards, forms an inclined plane directed downwards and backwards. It consists of a fibrous layer which is continuous with the neurilemma of the optic nerves; and of a very thin, semi-transparent, but very strong corneous layer (*lamina cinerea*), from which prolongations are given off to the upper surface of the optic commissure, and continued upon the optic nerves: these prolongations might be called the *grey roots of the optic nerves.* On dividing this horny layer, the third ventricle (*l*) is laid open; and it is seen that this layer forms a part of the general system of grey substance, which, on the one hand, is prolonged upon the lateral wall of the third ventricle and surrounds the anterior pillars of the fornix, and on the other is continuous with the tuber cinereum, above the optic commissure.

The Reflected Portion of the Corpus Callosum.

In front of the anterior part of the floor of the third ventricle is a transverse white mass, which is nothing more than the fore part (*e* to *m*) of the reflected corpus callosum. Terminating at this cross tract are two white fasciculi, which commence on each side at the point where the corresponding fissure of Sylvius meets the great transverse fissure of the brain; they then pass inwards and forwards, along the outside of the optic tracts, form the lateral boundaries of the anterior part of the floor of the third ventricle, and terminate by becoming applied to but not blended with each other, behind the reflected portion of the corpus callosum. Vicq d'Azyr has described these bands as the *peduncles of the corpus callosum.*

The Anterior and Inferior Part of the Longitudinal Fissure.

This (x, *fig.* 276.) is situated in front of the reflected portion of the corpus callosum, and can only be seen in its entire extent after the removal of a very dense fibrous layer which connects, sometimes very firmly, the back part of the right and left anterior lobes of the cerebrum. Not unfrequently one of these lobes is seen to encroach upon the other: the falx cerebri, which is very narrow in front, occupies only a very small portion of this fissure.

All the parts belonging to the median region of the base of the brain, which we have hitherto described, are situated in front of the pons Varolii; those which remain to be examined are placed behind it: they are, counting from behind forwards, the *back part of the longitudinal fissure*, the *posterior extremity of the corpus callosum*, and the *great horizontal* or *transverse fissure.*

The Back Part of the Longitudinal Fissure.

This is bounded in front by the posterior extremity of the corpus callosum (f), and as that extremity is at a greater distance from the back of the cerebrum than the anterior extremity of the corpus callosum is from the front of the brain, it follows that the back part of the longitudinal fissure is of much greater extent than the fore part (see *figs.* 277. 282.). Moreover, this part of the fissure is free throughout its whole extent, for it is entirely occupied by the base of the falx cerebri, whilst the fore part is only partially filled with the apex of the falx: it might even be said that the posterior lobes have a tendency to separate from each other in this situation.

The Posterior Extremity of the Corpus Callosum, and Middle Portion of the Great Transverse Fissure.

The *posterior extremity* (f, *fig.* 282.) *of the corpus callosum* is named the *bourrelet* *, in consequence of its being so much enlarged. This enlarged extremity, which we shall afterwards find is continuous with the posterior pillars of the fornix, constitutes the upper border of a fissure (r), the lower border of which is formed by the tubercula quadrigemina ($f\ g$). The pia mater (r to near k) enters at this *median fissure*, and forms the velum interpositum, or *tela choroïdea:* in this situation, also, is found the *conarium* or *pineal gland;* and it is here that Bichat described the orifice of his *arachnoid canal.* This median fissure becomes continuous with a lateral fissure on each side, so as to form the *great transverse cerebral fissure.*

The Great Transverse Cerebral Fissure.

The *great cerebral fissure* (*Bichat*), or the *great transverse* or *horizontal fissure*, follows a semicircular direction, having its concavity directed forwards; it commences at the fissure of Sylvius on one side (h, *fig.* 276.; above 2, *fig.* 282.), turns round the opposite cerebral peduncle, and ends at the opposite Sylvian fissure.

The peduncle of the cerebrum and the optic thalamus may be regarded as forming the root of each cerebral hemisphere. Now, the lateral part of the great transverse fissure passes round the posterior half of this root, because it is in this situation that the corresponding cerebral hemisphere is turned inwards upon itself. It is this reflected and concave surface of the hemisphere that forms the outer border of the corresponding lateral portion of the transverse fissure, whilst the optic thalamus forms its inner border. This fissure communicates directly with the inferior cornua of the lateral ventricles, and through it the pia mater enters those ventricles to form the *internal pia mater of the brain.*

* Cushion, thick border.

The Lateral Regions of the Base of the Cerebrum.

The base of the cerebrum is divided on each side into two lobes, an *anterior* and a *posterior*, separated by the *fissure of Sylvius.**

The Fissure of Sylvius.

This is a fissure of considerable size (grande scissure interlobulaire, *Chauss.*), which commences at the corresponding anterior extremity of the great transverse fissure, with which it forms an obtuse angle. At the point where they meet is found a white substance †, perforated with large openings for blood-vessels; this Vicq d'Azyr has named the *anterior perforated substance*; it is the *locus perforatus anterior* (*h*).

The fissure of Sylvius (*y*, *fig.* 276.) is directed outwards, and describes a slight curve, having its convexity turned forwards: it corresponds to the posterior border of the lesser wings of the sphenoid bone, which are received into it.

The fissure of Sylvius cannot be properly examined until both the arachnoid and pia mater have been removed. It is then found to be very deep: it is seen that the middle cerebral artery runs along the bottom of it, that the pia mater lines it throughout, and that it soon divides into two branches, of which the anterior is the smaller, and continues in the original course of the fissure; whilst the posterior, which is of much greater extent, passes upwards and backwards, along the convex surface of the hemisphere, and terminates after proceeding a variable distance; the interval between these two secondary furrows is occupied by a sort of *island* (insula, *Reil*), which might be called the *lobule of the fissure of Sylvius*, or the *lobule of the corpus striatum.*

This lobule is of a triangular form, having its base directed upwards and its apex downwards; it is marked by certain small superficial convolutions, which radiate from below upwards. It will be found immediately that this lobule corresponds to and is moulded upon the corpus striatum, which is sometimes so large as to push the lobule beyond the fissure, so that it reaches the surface of the brain, and appears to belong to the anterior lobe.

The Anterior and Posterior Lobes of the Cerebrum.

Several anatomists describe three lobes in each hemisphere upon the base of the brain, namely, an *anterior* (*a*), a *middle* (*c*), and a *posterior* (*b*); but there are only two — an *anterior* (*a*), which rests upon the orbital plate of the frontal bone, is moulded upon its irregularities, and is received into the concavity of that bone, and a *posterior* (*c b*), which rests upon the corresponding spheno-temporal fossa and the tentorium cerebelli. The anterior third of this posterior lobe, or the portion which corresponds to the spheno-temporal fossa, is convex, and projects from six to nine lines below the level of the inferior surface of the anterior lobe. The posterior two thirds are slightly concave; they correspond to the tentorium cerebelli, and are placed upon the same level as the anterior lobe. The convex sphenoidal portion of the posterior lobe forms what is generally called the *middle lobe*, and the posterior or cerebellar portion what is then named the *posterior lobe*. I believe that it is useful in many respects to apply the terms *frontal horn* (cornu frontale) to the anterior extremity of the cerebrum, which is received into the concavity of the frontal bone, *sphenoidal horn* to the anterior extremity of the posterior lobe, and *occipital horn* to the posterior extremity of the same lobe.

* [Three, according to other anatomists: an anterior (*a*, *fig.* 276.), a middle (*c*), and a posterior (*b*); the anterior separated from the middle by the fissure of Sylvius (*y*), the posterior resting on the cerebellum, or rather on the tentorium.]

† [Light grey.]

The Convolutions and Anfractuosities of the Cerebrum.

The entire surface of the cerebrum is marked by a great number of deep, winding furrows, which divide it into as many oblong eminences, turned in different directions, and themselves subdivided by secondary furrows. These eminences have some resemblance to the convolutions of the small intestine, and have been named, on this account, *convolutions*, *gyri*, *meandri*, *processus enteroidei*. The furrows by which they are separated are called *anfractuosities* or *sulci*.

A more accurate notion of the general character of these convolutions and anfractuosities may be obtained by supposing a bladder to be expanded round a compact central mass at a certain distance from it, and in this condition too large to be contained within the cranium; and then, that by means of threads proceeding from different points of the centre, the corresponding parts of the bladder are drawn inwards, so that it is folded upon itself, and can now be contained within the cranial cavity. The various winding folds and furrows produced in the walls of the bladder by drawing them from above and from all sides towards the centre, will give some idea of the arrangement of the surface of the cerebrum.

Some of the convolutions and anfractuosities are *constant*, because their forms are determined by those of the central mass; others are subject to *variety*, and seem to depend upon no determinate cause: these varieties occur not only in different brains, but also in the two hemispheres of the same brain. In this respect the human brain differs from that of the lower animals, in which the cerebral convolutions present much less variety, though they are not so constant as Vicq d'Azyr has stated.

The human brain is distinguished from the brains of the lower animals, not only by its size and weight, but also by the number and size of its convolutions. Tiedemann has given excellent representations of the progressive diminution of the cerebral convolutions (which is accompanied by a diminution of the cerebellum) from the apes to the rodentia and edentata.* In the human subject, as in the series of lower animals, the developement of the convolutions has always appeared to me to be directly proportioned to the developement of the entire brain.

In this point of view, as in many others, the human fœtus presents a similar structure to that found in the lower animals. The furrows or anfractuosities in the brain of the human fœtus at the fifth month are neither deeper nor more numerous than those in the brain of the rabbit; and it is important to study these primitive furrows, because they correspond to certain anfractuosities which ultimately regulate the whole system of convolutions. Thus, at the fifth month, the great anfractuosity, which is called the fissure of Sylvius, exists, but its borders are apart from each other; the island of Reil, or the lobule of the corpus striatum, is found upon the surface of the brain, and there is a longitudinal furrow at the lower and back part of the internal surface of each hemisphere — it corresponds to the occipital prolongation or posterior cornu of the lateral ventricle; there is also a furrow above the corpus callosum; and, lastly, the furrow of the olfactory nerve is visible. At birth, all the convolutions exist, but they are not completely developed until about the age of six or seven years.

It is impossible to determine the *number* of the convolutions, for they have no appreciable limits; and although some of them end between two adjacent ones, it is easy to see that this termination is merely apparent, and that near the point where it seems to take place, the convolution is continued into another without any line of demarcation. The ancient comparison, therefore, between the convolutions of the brain and those of the intestines, not only applies to their direction, but also to their continuity.

* [See also Leuret's figures in the work already referred to, in which will be found a comparative view of the number and arrangement of the convolutions of the brain in man and mammalia.]

There are several *orders* of convolutions. In fact, simple convolutions are seen to be divided, excavated, and furrowed, more or less deeply; but there are no regular and consecutive subdivisions as in the laminæ of the cerebellum. Vertical sections made in different directions will show the arrangement of the convolutions much better than the most careful observations of the external surface of the brain.

Each convolution presents to our notice *two surfaces*, a *base* or *adherent border*, and a *free border*. The *surfaces* of the corresponding convolutions are moulded upon each other, and separated by a duplicature of the pia mater.

The *base* or *adherent border* of each convolution is continuous with the central portion of the hemisphere (see section, *fig.* 277.).

The *free border* is slightly rounded, so that between any two contiguous convolutions there is a small groove, which is very distinct in cases of purulent infiltrations or depositions of lymph in the sub-arachnoid cellular tissue.

At the points where these convolutions meet, a triangular depression is observed. These spaces are small in the natural state, but become very evident in cases of atrophy of the convolutions.

The free border of some convolutions is frequently marked by an oblong depression or groove, varying in depth and extent, and following the direction of the convolutions: these depressions are sometimes sharp, and radiate into three or four branches; at other times they are superficial, or, lastly, deep and narrow. The arteries and veins which pass over the free borders of the convolutions form grooves upon them of various depths.

The free borders of most of the convolutions generally reach the surface of the brain; but besides the secondary convolutions, several of which remain concealed throughout their whole length, between two adjacent convolutions, there are some principal convolutions, which descend at one of their extremities between two adjacent convolutions; and there are others, again, which are depressed at one or at several points of their extent.

The *depth* of the convolutions varies from ten to fourteen lines, but it is extremely variable in different individuals: moreover, there are perhaps not two convolutions, nor two parts of the same convolution, which correspond in thickness in the same brain: some are considerably swollen, whilst others are narrow: there is almost always an enlargement at the point where two convolutions become continuous. Eustachius and Vieussens have erred, then, in representing all the convolutions as perfectly similar.

It would be undoubtedly curious to describe minutely all the convolutions. Vesalius, who appears to have entertained the idea of so doing, likened the appearance of the surface of the brain to those irregular forms which are traced by unskilful painters in delineating clouds. Vicq d'Azyr made an unsuccessful attempt to elucidate this subject; Gall and Spurzheim, who were interested in giving a minute description of each convolution, abandoned the task; I have myself attempted, and so has Rolando, to describe and name some of them. The description, however, to be understood, would require the assistance of figures; I shall, therefore, content myself with noticing, in this place, the most important convolutions upon the internal surface, upon the inferior surface, and upon the external surface, or convexity of each hemisphere.

Convolutions and Anfractuosities upon the Internal Surface.

The *convolution of the corpus callosum* is one which predominates over all those of the internal surface of the hemisphere; it is that which embraces the corpus callosum, and hence its name. It commences in front, below the reflected extremity of that body to which it adheres, passes forwards and upwards, turns round its anterior extremity, then extends backwards, and having reached beneath the posterior extremity of the corpus callosum, continues its course, and is arranged, in a manner to be presently described, upon the lower surface of the cerebrum.

It is narrow at its anterior extremity, which Rolando regards as the principal root of the olfactory nerve; it increases in size as it proceeds, and opposite the middle of the corpus callosum it is elevated like a crest, becomes much broader, and is marked by several furrows, of which some are superficial and others deep. The circumference of this broad crest is divided into several branches, which become continuous either with the superior convolutions of the convex surface, or with the posterior and superior convolutions of the internal surface of the hemisphere. Vicq d'Azyr first pointed out this crest of the convolution of the corpus callosum, and it was named by Rolando, *processo enteroido cristato.*

The *internal convolution of the anterior lobe* is eccentric in reference to the one just described, upon which it is moulded, a deep anfractuosity intervening between them. It is very large at its origin in front of the fissure of Sylvius; it forms the internal part of the anterior lobe of the cerebrum, and having arrived in front of the crest of the convolution of the corpus callosum, it passes upwards, and becomes continuous with the convolutions of the convex surface of the hemisphere.

This convolution is divided throughout its entire extent by a secondary anfractuosity, which is at first straight, and then sinuous.

Convolutions and Anfractuosities of the Digital Cavity.

A very deep longitudinal furrow, which corresponds to the digital cavity of the lateral ventricle, and like it constantly exists, extends from the convolution of the corpus callosum, near the posterior extremity of that body, directly backwards along the posterior lobe of the brain, which it divides into a superior and inferior portion. This *anfractuosity of the digital cavity* forms a division between the internal and inferior surfaces of the hemisphere.

The *convolutions of the digital cavity* are the two longitudinal and tortuous convolutions which bound this anfractuosity; the upper convolution belongs to the internal surface of the hemisphere, whilst the lower one forms part of the inferior surface.

Convolutions and Anfractuosities upon the Inferior Surface.

The great anfractuosity, called the *fissure of Sylvius*, divides the convolutions of the inferior surface into those of the anterior and those of the middle and posterior lobe.

The *convolutions of the anterior lobe* constantly found are, the two small, straight, longitudinal convolutions which bound the groove of the olfactory nerve (*l*, *fig.* 276.), and the flexuous convolution, which extends obliquely forwards and outwards, along the border of the fissure of Sylvius, and is continuous behind with the external straight convolution of the olfactory nerve.

The small convolutions and intervening anfractuosities are very irregular, and differ in different individuals, and even on the two sides in the same individual: into the depressions formed between these convolutions are received the prominent ridges seen upon the orbital plate of the frontal bone.

The convolutions of the (*middle and*) *posterior lobe.* The convolution which runs along the great transverse fissure is the continuation of the convolution of the corpus callosum, and terminates in front by an unciform enlargement, which corresponds to the dilated extremity of the cornu Ammonis; it forms the outer boundary of the great transverse fissure. The convolution of the corpus callosum and its continuation, viz. that of the transverse fissure, represent an ellipse, which is broken only at the fissure of Sylvius.

On the outer side of this convolution is a longitudinal anfractuosity, which corresponds to the lower wall of the inferior cornu of the lateral ventricle.

This anfractuosity is bounded by certain longitudinal convolutions, all of which proceed from the convolution of the transverse fissure, and are remarkable for their size and windings.

The most internal of these convolutions forms the lower boundary of the anfractuosity which I have said corresponds to the posterior cornu of the lateral ventricle.

From the anterior part of the convolution of the transverse fissure some extremely flexuous convolutions proceed from behind forwards, assist in forming the sphenoidal horn (point of the middle lobe), and become continuous with the convolutions of the external face of the hemisphere.

Convolutions and Anfractuosities of the Convex Surface.

The convolutions upon the convex surface of the hemisphere are undoubtedly the most complicated; on separating the borders of the fissure of Sylvius, within which the island of Reil is contained, it is seen that the fissure is triangular, and presents three sides: an *inferior border*, formed by the external convolution of the anterior lobe of the cerebrum; a *posterior border*, directed very obliquely upwards and backwards, which appears to receive all the occipital convolutions, and consists of a very tortuous convolution; and a *superior border*, also consisting of a very winding convolution, in which the majority of the superior convolutions terminate.

The convolutions upon the convex surface of the brain may be divided into the *frontal*, the *parietal*, and the *occipital*.

The *frontal convolutions* are three or four in number, and are directed from before backwards. The *parietal convolutions* are three in number; they pass in a serpentine direction from within outwards, and become continuous with the convolution which forms the superior border of the fissure of Sylvius. The *occipital convolutions* are directed from before backwards, and proceed, either from the posterior parietal convolution, or from the posterior border of the fissure of Sylvius.

The occipital convolutions are the narrowest and the most sinuous of all, so that the sides of the sinuosities of each convolution are in mutual contact in the greatest part of their extent, and touch the adjacent convolutions only at the points at which they are bent.*

The frontal convolutions are also very flexuous, and have similar characters to the occipital, but not so distinctly marked. They are larger than the occipital convolutions, but smaller than the parietal, which are, moreover, less tortuous than either of the others.

The unusual details with which I have described the convolutions can only be justified by the importance which has recently been attached to them. In the preceding description the following points have been noticed:— Their general disposition, their windings, and their mutual adaptation; their continuity, and the impossibility of drawing any precise limits between them; their general configuration, according to a common type, and the want of uniformity in their details, not only in different brains, but also in the opposite hemispheres of the same brain; their variable dimensions in different individuals, both in respect of depth and width, these being always directly proportioned to the size of the cerebral hemisphere: the individual differences both in the size of the brain and in that of the convolutions are very great.† We have also seen that the internal surface of the cranium is eactly moulded upon the surface of the brain, the digital impressions in the cranial bones corresponding to the convolutions, and the ridges or eminences to the small spaces intervening between the free borders of the convolutions.

Functions of the Convolutions and Anfractuosities.

The convolutions and anfractuosities render the surface of the brain of much greater extent than it would otherwise have been. According to Vesalius,

* In senile atrophy the occipital convolutions are chiefly affected.

† Comparative anatomy fully confirms this fact: the convolutions of a small hemisphere are very slightly developed, and they do not exist at all when the hemispheres are very thin, as in birds.

they are of use in multiplying the surface, through which the bloodvessels carry nutritious matter into the interior of the organ.*

The opinion that the anfractuosities and convolutions are intended to increase the surface, has been lately revived; but the supposed object of this increase is very different from that stated by Vesalius: thus, it has been agreed, that as there is an undoubted analogy between electrical phenomena and those manifested by the nervous system, and as electrical phenomena are developed, not in proportion to the quantity of matter concerned, but in proportion to the extent of surface, so the energy of the brain's action may be in a direct ratio with the extent of its surface. In support of this opinion the phenomena of arachnitis are quoted, in which disease delirium more frequently occurs than in inflammation of the cerebral substance itself. Allusion is also made to the folds observed in the retinæ of birds, which greatly increase the intensity of vision: M. Desmoulins, who is a principal supporter of this theory regarding the use of the convolutions, states that he has observed these folds to disappear in birds which had been kept in the dark, in the same way that the cerebral convolutions become atrophied, either from the continued absence of all cerebral excitement, or from any other cause of intellectual weakness.

The anatomists and philosophers of antiquity, considering that the convolutions were more highly developed in man than in the lower animals, concluded that the intellectual superiority of the former was owing to this circumstance. Such was the opinion of Erasistratus, facetiously refuted by Galen.†

Gall and Spurzheim have recently revived this old opinion, and assuming with some philosophers the existence of a plurality of mental functions, they have arrived at the conclusion that there is also a plurality of material instruments or organs, by which those functions are performed. These material organs are supposed by them to be the convolutions, upon which they accordingly placed numbers corresponding to the different mental faculties admitted by their philosophy: the difficulty was to settle on the number of primitive mental faculties and their corresponding organs. According to Gall and Spurzheim, the highest intellectual faculties of man are seated in the anterior lobes of the cerebrum.

On the other hand, from an examination of the brains of fifty insane patients, M. Neumann has been led to think, that the occipital portion of the cerebrum is the seat of intelligence: this opinion derives some support from a fact, which I have myself often observed, viz. that atrophy of the brain of old persons in insanity affects the occipital more than the frontal convolutions; and also by the fact, that as we descend in the animal series, the posterior part of the brain is observed to be the first to diminish, and then entirely to disappear.

It is unfortunate for the system of Gall, that the convolutions form a continuous whole, and are not separated into distinct organs; and it is also unfortunate that upon the base of the cerebrum, and upon the internal surface of each hemisphere, there are convolutions as distinctly marked as those upon the convex surface. And yet, in the system of Gall, the convolutions upon

* The substance of the brain, says Vesalius, is not firm enough for the arteries and veins to traverse it with impunity; on the other hand, it is so thick, that bloodvessels distributed over its surface would not have been sufficient to nourish the entire mass; and therefore nature has provided certain deep and winding furrows upon the brain, into which the pia mater can penetrate, so as to convey to the deep-seated parts the materials for their nutrition; for the same reason, the cerebellum has been divided into laminæ and lamellæ. Vesalius even states that the division of the cerebrum into two hemispheres is for no other purpose. (Lib. vii. cap. 4. p. 542.)

† "Quum asini etiam admodum multipliciter cerebrum habent complexum quod deceret, quantum ad morum ruditatem attinet, omnifariam simplex et minime varium nancisci cerebrum." If this theory be true, says Galen, the ass ought to have a brain with a smooth surface and no convolutions; but it has numerous and deep convolutions: the intellectual faculties, therefore, are independent of the convolutions. The conclusion is not obviously contained in the premises.

the base and internal surface of the hemispheres have been, so to speak, disinherited; for all the mental faculties have been located by him in the convolutions of the convex surface.

The Internal Structure of the Cerebrum.

In order to make as complete an examination of the internal conformation of the brain as is possible in the actual state of science, it should be prosecuted by means of sections in different directions; by tearing the brain, and by acting upon it with streams of water; and by dissecting brains that have been hardened by alcohol, or by being boiled in oil or in a strong solution of salt.

Examination of the Internal Structure of the Brain by Sections.

This mode of examining the brain was the one employed by Galen, it was revived by Vicq d'Azyr, and is now generally adopted.

By means of these different sections it is easy to study the internal conformation of the brain in its principal details. The other methods are more especially adapted for determining the connections of the several parts of the cerebrum with each other, or with the other portions of the cerebro-spinal axis. I shall commence by an examination of horizontal sections of the brain.*

Horizontal Sections of the Brain.

On making an incision into the brain, this organ is found to consist of two substances — a *grey cineritious* or *cortical* substance, and a *white* or *medullary* substance, which is surrounded on all sides by the grey. †

First section. A horizontal section, made so as to remove the *upper half* of the superior *convolutions* of the cerebrum, shows that each convolution consists of a central white portion, surrounded on all sides with a layer of grey substance; that the grey substance is accurately moulded upon the white, the form of which determines that of the corresponding convolution; that the thickness of the grey matter varies from half a line to a line and a half; and that it is far from being uniform, either in the same or in different convolutions. In judging of the thickness it is important to have regard to the direction of the section, for it is easy to understand that an oblique section of the grey matter will give a very different result from one made perpendicularly. The section described above also shows that the convolutions are continuous with each other, and it enables us to comprehend their irregular, complex, and sinuous arrangement better than could be done without cutting into the brain.

The relative *proportion* of the grey and white substances in each convolution may be determined approximately by macerating a brain for some days; the grey substance being softer and more readily decomposed, is thus converted into pulp, and may be easily removed. The convolutions being thus reduced to the white substance only, appear like short white lamellæ, arising from different points of the surface of the central medullary mass. I estimate the grey matter at about five sixths of each convolution.

Second section. A horizontal section made beneath the base of the convolutions of the convex surface of the hemispheres, presents an appearance like that of a geographical chart, of a deeply and irregularly indented coast; an appearance which cannot be described without figures. It consists of a central mass of medullary substance, which is narrowed like an isthmus behind: extending from this central mass are certain prolongations, which may be divided into several orders, and which are themselves subdivided, so as to form the medullary centre of each convolution.

Third section. A horizontal section, made on a level with, or rather just

* The sections should be made with a very sharp instrument, a razor, for example.

† See note, p. 935.

above, the corpus callosum, displays a great medullary centre in each hemisphere (centre médullaire hémisphéral; centrum ovale minus; *a c b*, *a c b*, *fig.* 277.).

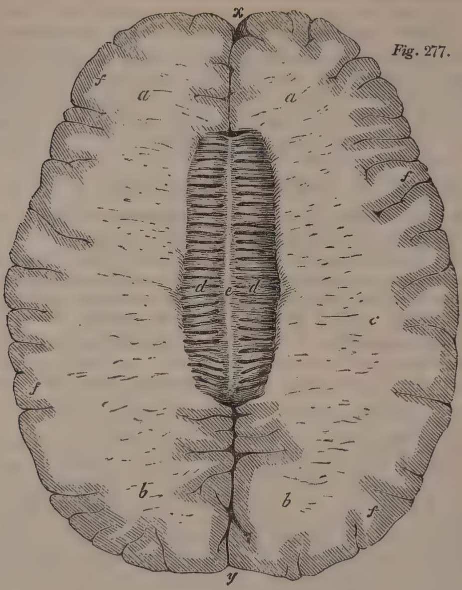


Fig. 277.

The two centres of the opposite sides together with the corpus callosum (*d d*) form the *centrum ovale of Vieussens.*

The *centrum ovale of Vieussens* is contracted in the middle line, where it is formed by the corpus callosum, but is much larger in each hemisphere. The anfractuosities by which the circumference of this section is indented are seen to be deeper on the outside and behind, than on the inside and in front.

By the three horizontal sections just described, it is shown that each convolution (*f f f*) consists of a white central portion surrounded by a thick layer of grey substance, having a precisely similar shape; that it is the grey matter which predominates in the convolutions; that the central portions of all the convolutions are continuous with each other, and form the most complicated windings; that they all rest upon a hemispherical central mass, which becomes larger and larger towards the corpus callosum, on a level with which it attains its greatest dimensions; that the centrum ovale of Vieussens, which however is not oval, represents the largest medullary surface of the brain, and might be regarded as a centre from which all the radiations that enter the convolutions are given off in one direction, and in the other, all those which establish connexions between the brain and the other parts of the cerebro-spinal axis; lastly, that the centrum ovale and the convolutions are always developed in a corresponding ratio.

The Corpus Callosum.

If when the brain is resting upon its base, the two hemispheres be drawn asunder, a transverse white band is seen at the bottom of the longitudinal fissure, extending from one hemisphere to the other, and connecting them

together, and forming their commissure: this band is the *corpus callosum* * (mésolobe, *Chaussier*; commissura cerebri magna, maxima, *Reil, Soemmerring*; *d d*). On removing the upper part of the two hemispheres by a horizontal section made about a line or two above the corpus callosum, it is seen that each hemisphere encroaches upon the corpus callosum and overhangs it without adhering to it: the interval between the hemisphere and the corpus callosum has been improperly termed the *ventricle of the corpus callosum.* But there is no cavity here, nor is there a smooth exhalant and absorbing surface; it is merely an anfractuosity, separating the corpus callosum from the convolutions, and lined by the pia mater like all other anfractuosities. On continuing to remove successive portions of the hemisphere, it is found that it can be separated without any laceration from the corpus callosum much farther than the point at which the pia mater is reflected, and that the hemisphere and corpus callosum are simply in contact with each other; the fibres of the hemisphere are seen to be longitudinal, whilst those of the corpus callosum are transverse.

From this observation it follows, that the middle or free portion of the corpus callosum (shown in *fig.* 277.) is but a small part of that body.

The corpus callosum reaches much nearer to the anterior (x) than to the posterior (y) extremity of the cerebrum, being an inch and some lines distant from the former, and from two to three inches from the latter.

Its *length* is about three inches and a half; it is *broader* behind than in front; its breadth behind varies from eight to ten lines, if we include the part which is covered by the hemispheres: its *thickness*, which can be properly shown only upon a vertical section (see *fig.* 282.), along the middle line, is not uniform throughout; its thickest part is at the posterior extremity (f), which is about three lines thick: in front of this extremity it diminishes abruptly, and is scarcely a line or a line and a half in thickness (d); it then gradually increases from behind forwards, and is about two lines thick at its anterior extremity, opposite the point of its reflection (e).

In *form* the corpus callosum resembles an arch or *vault*, so that it would deserve the name of vault or fornix better than the part usually so called.

Its vaulted form is distinctly shown upon a longitudinal vertical section (*fig.* 282.), and at the same time it is seen that the posterior extremity of the corpus callosum is rolled up, as it were, so as to form an enlargement, while its anterior extremity is merely reflected downwards and backwards, and after its reflection becomes gradually thinner as it descends, and terminates in a very delicate lamella.

The corpus callosum presents for our consideration a superior and an inferior surface and two extremities. The *superior surface* is convex, and as it were arched from before backwards (*medullaris arcus*); it has no raphé along the median line, but presents in that situation a slight groove (*e, fig.* 277.), depending on the existence of two white longitudinal tracts, one on each side the middle line, which were regarded by Lancisi as constituting a nerve, *the longitudinal nerve of Lancisi.*

These tracts are subject to variations: thus they are sometimes slightly flexuous and contiguous to each other, and at other times they unite and then separate. Duverney has described certain ash-coloured longitudinal tracts, but their existence has been denied by most anatomists.

The white longitudinal tracts are intersected at right angles by transverse fasciculi, which constitute the corpus callosum.

The upper surface of the corpus callosum corresponds to the hemispheres on each side; it is free in the middle, where it corresponds to the arteries of the corpus callosum and to the free margin of the falx, which has appeared to me to approach very closely to the posterior extremity of this body, but not to touch it, so that it could not occasion any depression upon it.

The *inferior surface of the corpus callosum* is concave, and is free over a

* According to Haller, its name is derived from its whiteness, which has been compared to the colour of a cicatrix; according to others, it was given on account of the consistence of this part, which has been erroneously regarded as exceeding that of other parts of the brain.

greater extent than the superior; it forms the upper wall or roof of the lateral ventricles (*i i*, *fig.* 278., in which figure only the anterior and posterior extremities, *e* and *d*, of the corpus callosum are left).* This surface is covered by the serous membrane of the ventricles, and, like the superior surface, it is fasciculated.

Along the median line it corresponds, in front, to the septum lucidum, (*t*, *figs.* 278. 282.), and behind to the fornix (*k*), with which it even seems to be united at this point. In consequence of the somewhat regular arrangement of the fibres constituting the two posterior pillars of the fornix (*r r*, *figs.* 278, 279.), which diverge in this situation, and also of that of the transverse fibres of the corpus callosum, the back part (*s*, *fig.* 279.) of the inferior surface of the corpus callosum has received the names of *lyra*, *corpus psalloides*, *psalterium.*

The *posterior extremity* of the corpus callosum (bourrelet, *Reil*), which as we have already stated is its thickest part, is slightly concave transversely, but presents no other notch, excepting the median depression, between the longitudinal tracts. †

The *anterior extremity of the corpus callosum* does not terminate in an enlargement like the posterior, but it is reflected, and embraces the anterior extremity of the corpus striatum: it then passes downwards and backwards (*e*, *fig.* 282.), and terminates insensibly in front of the anterior portion (*m*) of the floor of the third ventricle. Reil applies the term *knee* (*genu*) to the point of reflection, and that of *beak* (*rostrum*) to the posterior and thin extremity of the reflected portion. This reflected portion of the corpus callosum is seen upon the base of the brain, between the anterior lobes: the convolution of the corpus callosum also accompanies its reflected portion, and instead of being merely in contact becomes continuous with it, so that the grey matter rests immediately upon the corpus callosum. The longitudinal tracts arise from the reflected portion of the corpus callosum; and the inferior peduncles of the corpus callosum (*Vicq d'Azyr*), already mentioned, terminate upon this portion.

The right and left borders of the corpus callosum enter deeply into the substance of the hemispheres.

Beneath the corpus callosum are situated, in the median line, the *septum lucidum* (*t t*, *fig.* 278.), the *fornix* (*k*), the *velum interpositum* (*v*, *fig.* 279.), and the *median* or *third ventricle* (*c* to *x*, *fig.* 280.); and at the side, the *lateral ventricles* (*i i*, *fig.* 278.). We shall proceed to examine these different parts in the above mentioned order. To obtain a good idea of their form and relations it is important to study them upon two brains, one resting upon its convex surface, and the other upon its base.

The Septum Lucidum.

The *septum lucidum*, or transparent septum, so called, because it separates the lateral ventricles from each other, and is semi-transparent, is situated in the median line (septum médian, *Chauss.*). It is very well seen (*t*, *fig.* 282.) when the corpus callosum has been divided longitudinally on each side of the middle line. It appears like a thin lamina given off from the anterior and inferior part of the corpus callosum, and passing vertically downwards in front of the fornix; it is of a triangular shape, broad in front and narrow behind; its lateral surfaces constitute the internal walls of the lateral ventricles; its upper border is continuous with the corpus callosum, its posterior with the fornix, and its inferior with the reflected portion of the corpus callosum in front, and with the inferior peduncles of that body further back. Hence Vicq d'Azyr imagined that the septum lucidum was a continuation of these peduncles.

The septum lucidum is composed of two very delicate and completely

* The best mode of examining the lower surface of the corpus callosum is to view it by opening the ventricles from the base of the brain.

† One is astonished to read in Chaussier's work, that the notch of the posterior extremity of the corpus callosum is caused by the alternate movements of elevation and depression of the brain. At each elevation, according to him, this extremity of the corpus callosum strikes against the free margin of the falx cerebri, although that margin is at some slight distance from it.

distinct lamellæ (*t t*, *fig*. 278.), between which, in front, a cavity is inclosed, containing a few drops of a serous fluid ; this small cavity is called the *ventricle of the septum*, the *first ventricle* (*Wenzel*), the *fifth ventricle* (*Cuvier*), and the *sinus of the median septum* (*Chauss.*); it is not very unfrequently the seat of dropsical effusion. I have found it filled with blood in several subjects after death from apoplexy.

As to whether this ventricle of the septum communicates with the other ventricles, opinions are divided. Tarin describes a small fissure opening between the anterior pillars of the fornix, but the majority of anatomists have not been able to demonstrate it. It appears to me that the absence of all communication is a well ascertained fact.

Each of these lamellæ of the septum lucidum consists of a medullary layer, covered on the outside by the membrane of the corresponding lateral ventricle, and on the inside by the membrane of the fifth ventricle. The existence of this last mentioned membrane is proved by the smooth appearance of the ventricle, and it may be demonstrated by removing, in succession, layers from the outer surface of the lamella. The grey matter of the third ventricle is prolonged upon the external surface of each lamella of the septum.

The Fornix and Corpus Fimbriatum.

The *fornix* (la voute á trois piliers ; *k*, *r r*, *fig*. 278.) is a medullary arch, situated (*k*, *fig*. 282.) beneath the corpus callosum, with which it is continuous

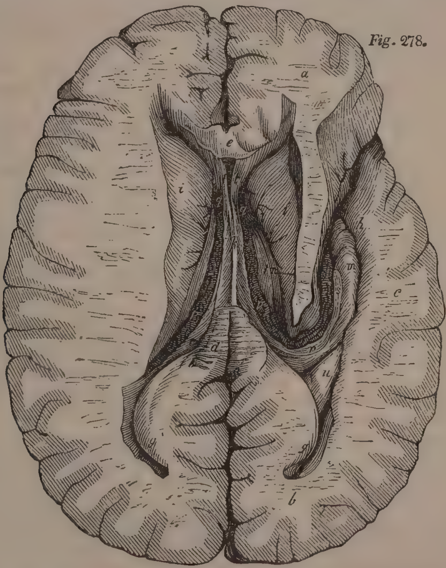


Fig. 278.

behind, but which it leaves in front, and then passes perpendicularly downwards, describing a curve within the curvature of the corpus callosum. The interval between the anterior part of the fornix and the corpus callosum is occupied by the septum lucidum. To the term fornix, used by the older writers, the epithet *à trois piliers* has been improperly added by Winslow, inasmuch as it expresses a mere appearance ; for there are in reality *four* pillars, the two anterior of which are closely approximated to each other, whilst the two posterior are widely apart.

The fornix resembles an isosceles triangle (*trigone cérébral*), having the anterior angle very much elongated and soon bifurcated; its posterior angles suddenly diverge, pass downwards and outwards, and are prolonged (*r r*) into the inferior or reflected portions or descending cornua of the lateral ventricles, where they constitute the *corpora fimbriata* (*s*), or rather the fornix may be said to be composed of two perfectly distinct medullary cords, which are applied closely to each other, become broader and flatter as they proceed backwards and downwards, and separate from each other opposite the reflected portions of the lateral ventricles, into which they enter. The fornix, therefore, resembles the letter *X* placed horizontally, the anterior limbs of which are close to each other (between *q q*) and very short, whilst the posterior limbs (*r r*) are very long and widely apart. The term fornix is really applicable only to that portion which is applied to the corpus callosum. Reil, who has described and figured this part better than any of his predecessors, not even excepting Vicq d'Azyr and Soemmerring, calls the fornix the twain-band.

The *superior surface* of the fornix corresponds, in the median line, to the septum lucidum in front, and to the corpus callosum behind: on each side it is free and forms a part of the floor of the lateral ventricles. The choroid plexuses (*p p*) are sometimes reflected upon this surface of the fornix.

In order to understand the relations of the fornix with the corpus callosum, it is necessary to bear in mind that it is composed of two flat medullary bands. Now the internal contiguous borders of these bands are turned upwards, and adhere to the lower surface of the corpus callosum, so as to form a small vertical septum, which is continuous with the back part of the septum lucidum. The medullary fibres of the septum lucidum are therefore generally considered to be continuous with those of the fornix.

The *inferior surface of the fornix* (*r r*, *fig.* 279.) rests upon the *velum interpositum* (*v*), which separates it from the third ventricle (*c b x*, *fig.* 280.) and the optic thalami (*l l*), the internal portion of which bodies is covered by the fornix (see *fig.* 278.). It is upon the posterior portion of this inferior surface, where the two medullary bands of the fornix separate from each other to enter the descending cornua of the lateral ventricles, that we find that regular though variable arrangement of transverse fibres (*s*), abutting on certain longitudinal fibres (*r r*), which has been named the *lyra*, *corpus psalloïdes* or *psalterium*. I have already noticed this structure, which was erroneously regarded by Gall as composed of the uniting fibres of the fornix.

The *edges* of the fornix are thin and free, and are bordered by the choroid plexuses.

The *anterior pillars* of the fornix (*k*, *figs.* 279, 280.), which Vieussens, Tarin, and others described as arising almost indifferently either from the cerebral peduncles, or from the anterior commissure (*c*, *fig.* 280.; situated in the third ventricle), can only be well seen in a longitudinal vertical section of the cerebrum made exactly in the median line. Each half of the cerebrum will contain the corresponding band of the fornix; and it will then be seen, as was first described by Santorini, that each anterior pillar (seen below *k* and behind *c*, *fig.* 282.) arises from the corpus albicans (*z*) of its own side: hence these bodies have been called the *bulbs of the fornix*. The whole of the white covering of each of the corpora albicantia (*l*, *fig.* 283.) appears to be formed into a thick white fasciculus or cord, which passes upwards, and may be very easily traced with the handle of the scalpel through the soft grey matter which forms the inferior and anterior portion of the wall of the third ventricle. Whilst passing through this grey matter the cord describes a curve, having its concavity turned backwards, and is situated between the optic thalamus and the corpus striatum, and behind the anterior commissure (*c*, *fig.* 282., *m*, *fig.* 283.); having emerged from the grey matter, which is still prolonged along its anterior surface and thus reaches the septum lucidum (*t*), the anterior pillar is reflected backwards (*h*, *fig.* 283.) in front of the optic thalamus, and becomes changed into a flat band (*k*, *fig.* 282.), which is applied to the thalamus (*l*), and follows the contour of that body: at

the point where the anterior pillar of the fornix changes from an ascending to a horizontal direction, it forms half a ring (situated behind and below *k*, *fig.* 282.), which is completed by the anterior part of the optic thalamus. This is the opening of the *foramen of Monro*, by which a communication is established (opposite *q q*, *fig.* 278.) between the third and the corresponding lateral ventricles.

The posterior pillars. Having arrived opposite the back part of the optic thalamus, each of the lateral bands of the fornix, which had already been directed somewhat obliquely outwards, passes abruptly and very obliquely outwards and downwards (*r r*) into the descending cornu (*h*) of the corresponding lateral ventricle, and is there divided into two parts, one of which forms the superficial medullary substance of the cornu ammonis, or hippocampus major (*m*), whilst the other follows the concave border of the hippocampus, and takes the name of *corpus fimbriatum* (*s*), *corps frangé*, *corps bordé.* We shall again allude to these parts in describing the lateral ventricle.

I have said that the anterior pillars arise from the corpora albicantia, but they have a much deeper origin, which was figured by Vicq d'Azyr, and has been still better described by Reil. According to that anatomist they arise within the optic thalami. I have traced them much further than Reil, as far as the *tænia semicircularis* on each side; or rather each *tænia semicircularis* (*n*, *fig.* 278.), which is situated in the lateral ventricle between the corpus striatum (*i*) and the optic thalamus (*l*), and which is continuous with the anterior corpus quadrigeminum or natis of its own side, becomes subdivided into two bands, which may be regarded as the roots of the corresponding anterior pillar of the fornix. Of these two roots one is superficial (*n*), and easily seen without dissection, the other is deep-seated (*v*, *fig.* 283.), enters into the substance of the optic thalamus, runs forwards to the corpus albicans (*l*), spreads out and forms the surface of that body, and then curves upwards to constitute the anterior pillar of the fornix (*h*), at the point where it emerges from the grey matter.

The two bands of the fornix also receive some other white fibres, which greatly multiply its connexions. Thus, as they are traversing the grey matter, the anterior pillars receive additional medullary fibres, some arising from the grey matter itself, and others from the commissure of the optic nerves; again, just as they emerge from the grey matter to become horizontal, they receive a considerable cord, formed conjointly by the white fibres covering the optic thalamus (*g*, *fig.* 283.), by a white band, which runs longitudinally along the optic thalamus, and is continuous with the corresponding peduncle of the pineal gland, and by the superficial fibres of the tænia semicircularis, of which I have already spoken. These three sets of fibres form a cord of considerable size, which is bent abruptly backwards, and becomes continuous with the fornix. Lastly, the fornix receives, or perhaps it gives origin to the white radiated fibres of the septum lucidum.

The Velum Interpositum.

Beneath the fornix is situated a vascular membrane, a prolongation of the external pia mater: this is the *velum interpositum*, or *tela choroidea* (*v*, *fig.* 279.), so named by Herophilus from its tenuity, which he compared to that of the fœtal membrane called the chorion.

It is thus formed: the external pia mater having arrived below the enlarged posterior extremity of the corpus callosum, penetrates (at *r*, *fig.* 282.) into the interior of the brain between that body and the tubercula quadrigemina, and forms a sort of triangular web (*v*, *fig.* 279.), the base of which is turned backwards and the truncated and bifurcated apex forwards. The *upper surface* of the velum is covered by the fornix (reflected at *r r*), to which it transmits a great number of vessels. Its *inferior surface* forms the roof of the third ventricle, and corresponds on each side to the upper and to a small part of the inner surface of the optic thalami (*l l*). The velum is also in relation with the

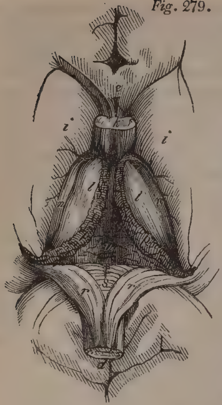


Fig. 279.

venæ Galeni and with the pineal gland (*p*, *fig.* 282.), adhering very closely to that body, and forming a nearly complete investment for it, so that they are almost always removed together. Bichat described his so-called arachnoid canal as passing beneath the velum interpositum. Upon the lower surface of the velum, which can only be properly examined from below, are found two small trains of red granulations, precisely similar to the choroid plexuses of the lateral ventricles, with which they are continuous in front: they may be called the *choroid plexuses of the third ventricle.*

The lateral *borders* of the velum are continuous with the upper part of the choroid plexuses (*p p*, *figs.* 278, 279.) of the lateral ventricles.

The *anterior extremity*, or apex of the velum, is bifid; each branch of the bifurcation passes from the third into the corresponding lateral ventricle (behind *k*, *fig.* 282., opposite *q q*, *fig.* 278.), behind the anterior pillar of the fornix, and constitutes the anterior extremity of the choroid plexus.

The velum interpositum is formed by the pia mater, supported by a tolerably strong fibrous layer.

When the fornix and the velum (as in *fig.* 280.) are removed, we arrive at a cavity, called the *middle* or *third ventricle.*

The Middle or Third Ventricle.

Dissection. In order to expose the third ventricle from the base of the brain, the right peduncle of the cerebrum and the right corpus albicans should be separated from those of the left side by a longitudinal section in the median line. There is another section, which I recommend as exceedingly well adapted to exhibit all the parts contained in the third ventricle; it is made from before backwards, and on either the right or left side of the median line, so as to leave both of the lateral walls of the third ventricle uninjured.

The *third ventricle* (*c* to *x*, *figs.* 280. 282.) is situated in the median line, near the base of the brain, between the optic thalami (*l l*, *fig.* 280.) and in front of the tubercula quadrigemina (*f g*): it appears like a very narrow cavity, oblong from before backwards, and of greater extent below than above; it is not so much a cavity as a fissure between the two optic thalami. Vesalius compared this ventricle to a valley, the hills on either side of which were very closely approximated to each other, and united by a sort of bridge, represented by the commissura mollis (*b*).

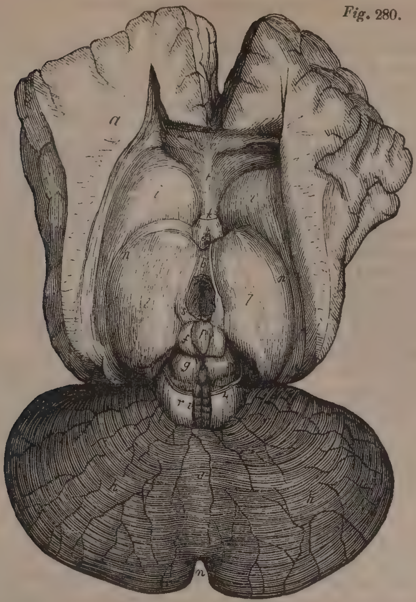
The *superior orifice* of the third ventricle is surrounded by a white rim or border (*s*), which forms, behind and on either side, the peduncles of the pineal gland.

The *lateral walls* (*l*, *fig.* 282.) are plane, smooth, and of a grey colour; they are formed by two very distinct parts, viz. above and behind by the internal surface of the optic thalamus, and below and in front by the internal surface of a grey mass, which appears to me to deserve a particular description under the name of the grey mass of the third ventricle.

That part of the internal wall of the ventricle which is formed by the optic thalamus is marked off by a horizontal groove from the part formed by this grey mass.

The internal surface of this grey mass is smooth and lined by the membrane of the ventricle. The external surface is continuous with the rest of the brain; below, it forms the tuber cinereum, or base of the infundibulum, passes around the corpora albicantia, the anterior pillars of the fornix and their roots, is

Fig. 280.



prolonged upwards upon the sides of the septum lucidum, and downwards as far as the upper surface of the optic commissure, the posterior border of which is imbedded in this grey mass and receives from it a short white root on each side.

The lateral walls of the third ventricle are united together, opposite the anterior part of the optic thalami, by a grey substance called the *soft commissure, commissura mollis* (*b*), the *grey commissure*, and also the *vascular commissure of the optic thalami*; it varies much in size, and is very easily torn; but I have always found the remains of it in those cases in which it appeared at first sight to be wanting.* I regard the soft commissure as a prolongation of the grey mass of the third ventricle, and this substance appears to me to be of the same nature as the grey matter of the convolutions.

The *floor of the third ventricle* is of greater extent than the walls of that cavity; it is concave upon its upper or ventricular surface, and convex below. We shall divide it into three portions: the *posterior portion of the floor* (above *n*, *fig.* 282.) is deeply grooved along the median line, forms an inclined plane sloping downwards and forwards, and corresponds to the interval between the peduncles of the cerebrum; its white colour, which is scarcely concealed by the thin layer of grey matter upon it, contrasts strongly with the distinct grey colour of the lateral walls. The *middle portion of the floor* is funnel-shaped, and corresponds to the corpora albicantia (*z*), and to the infundibulum (*i*); it leads to the canal in the infundibulum. The *anterior portion of the floor* (*m*) is inclined downwards and backwards, and is formed by a very thin, semi-transparent layer of grey substance (*lamina cinerea*), which we may call with Tarin,

* Out of sixty-six brains of subjects of all ages examined by the brothers Wenzel, the soft commissure was found in fifty-six. It was, therefore, wanting in ten cases. The facility with which it is lacerated may have misled these industrious investigators into a belief that its absence was more frequent than it actually is.

the *pars pellucida*, and which is supported by a fibrous layer derived from the pia mater.

In front, the third ventricle presents the *anterior pillars* (*k*, *fig.* 280.; below *k*, and behind *c*, *fig.* 282.) of the fornix, in front of which is situated a white, cylindrical cord (*c*), directed transversely, and visible only in its middle portion; this is the *anterior commissure*, beneath which the ventricle extends as far as opposite the posterior border of the optic commissure. Behind the anterior pillars of the fornix, and somewhat above the anterior commissure, are the *two openings* by which the third ventricle communicates with the lateral ventricles (*foramen Monroi*); these openings (of which one is seen between *b* and *k*, *fig.* 282.) are of an oval shape, are sometimes of unequal size, and become much enlarged in chronic effusion into the ventricles. The two divisions of the anterior extremity of the velum interpositum pass through these openings to become continuous (at *q q*, *fig.* 278.) with the choroid plexuses. Haller erroneously regarded them as accidental; an opinion that was founded upon several pathological observations, from which it appeared that the lateral ventricles were distended with a considerable quantity of fluid whilst the third ventricle remained empty.

At the back part of the third ventricle is seen the *posterior commissure* (*x*, *figs.* 280. 282.), a transverse cylindrical cord, situated in front of the tubercula quadrigemina, and below the commissure of the pineal gland, with which it is continuous. The posterior commissure is smaller than the anterior; it may be regarded as a white commissure of the optic thalami, for its extremities are lost in their interior. It forms a sort of bridge above the anterior orifice of the aqueduct of Sylvius.

The Aqueduct of Sylvius.

The *aqueduct of Sylvius*, or aqueduct of the corpora quadrigemina, which was described by both Galen and Vesalius, and by the latter quite as perfectly as by the anatomist after whom it is named, is a canal which establishes a communication between the third and fourth ventricles (*l v*, *fig.* 282.)—*iter a tertio ad quartum ventriculum*; it passes through the isthmus of the encephalon, in the median line, below the tubercula quadrigemina (*f g*). It is directed obliquely downwards and backwards. Its walls are dense and lined by the membrane of the ventricles. This canal presents both on its upper and its lower wall a longitudinal groove or median furrow, bounded by two small longitudinal cords. The median furrow on the lower wall is continuous with the longitudinal groove of the calamus scriptorius. The brothers Wenzel have given a minute description of these two furrows, and they have also noticed two lateral furrows. It was stated by Vieussens, that the opening of the aqueduct into the fourth ventricle was provided with a valve. But his statement is at variance with the results of observation.

It follows, therefore, from the preceding description, that the third ventricle has four openings: two of which communicate with the lateral ventricles, the third opens into the fourth ventricle, and the fourth (between *b* and *x*, 280.) leads into the infundibulum.

The third ventricle, moreover, has three commissures: one composed of grey matter. viz, the commissura mollis, or commissure of the optic thalami, the other two of white substance, one being anterior and the other posterior.

The Conarium, or Pineal Gland.

The *conarium*, *pineal gland*, or pineal body, is a small greyish body (*p*, *figs.* 280. 282.), situated in the median plane, behind the posterior commissure of the third ventricle, and between the nates, upon which it rests.

It is retained in this situation by two small medullary cords, which are called its peduncles, and by the velum interpositum below which it is placed, and by which it is almost completely invested as with a closely adherent

sheath: the adhesion between these parts is so intimate that they are almost always removed together; and hence some anatomists have regarded the conarium as a dependence of that membrane, and others, who have not been careful in their examinations, have declared that it is sometimes wanting in the human subject. This body, however, always exists in man and the mammalia. It is wanting in birds and fishes, and in reptiles, with the exception of the tortoise, in which it is so remarkably large that it forms by itself a kind of brain. (Desmoulins, *Anat. du Syst. Nerv.* t. i. p. 211.)

This body is shaped like a cone, having its adherent base turned forwards and its free apex backwards; hence its name of *conarium* (*Oribasius, Galen*); it has also been compared to a pine-cone, and has been named the *pineal gland*, or *pineal body*. Its form, however, is subject to some variety; it is sometimes spheroidal, and at other times cordiform, from being notched at the base.

The pineal body is small, being only about four lines in length, and from two to three lines wide at the base. Its size, in the animal series, does not appear to bear any proportion to the size of the cerebrum, or of the cerebellum, or of the tubercula quadrigemina, so that comparative anatomy throws no light upon this obscure subject. Neither age nor sex have any influence upon the developement of this small body.

Relations. The conarium or pineal gland, inclosed in the pia mater, like the cerebrum and cerebellum, rests upon the slight triangular depression between the nates: the venæ Galeni run along its sides.

When stripped of the pia mater, it is free in all directions, excepting at its base, which is connected with the encephalon by a *transverse commissure* situated above the posterior commissure of the cerebrum, and by *four slender peduncles*, two of which are superior and two inferior. The *superior peduncles* (*s*, *figs.* 280. 282.), which are the only ones generally described, form together a sort of loop, the two ends of which run along the tops of the optic thalami; they have been named the reins of the pineal body (*habenæ*). We have already seen that they are continuous with the fornix. The *inferior peduncles*, which are distinctly seen only upon a longitudinal vertical section through the middle of the cerebrum, arise from the base of the pineal body, pass vertically downwards upon the back part of the internal wall of the third ventricle, and may be traced to the lower part of that cavity.*

Colour and consistence. The reddish-grey colour of the pineal body contrasts strongly with the whiteness of its commissure and peduncles. The colour and consistence of this body exactly resemble those of the grey matter of the cerebral convolutions. If it be compressed between the fingers, a viscid juice exudes, and certain small concretions are found in it, which I shall notice after having described the structure of this organ.

Structure. At the base of the pineal body are seen some white or medullary fibres which arise from the commissure and from the superior peduncles of that organ. These white fibres spread out into a tuft and terminate abruptly. All the rest of the conarium consists of grey matter. On making a horizontal section of this body, it is sometimes found to be solid, and sometimes to be hollow, and to contain a transparent, viscid fluid. The cavity is lined by a vascular membrane, and, according to Meckel, by a layer of medullary substance, which I have never seen. It has been stated that it communicates with the third ventricle; but I am inclined to believe with Santorini and Gerardi, that the communicating orifice admitted by some authors is the result of traction upon the base of the conarium in attempting to remove the pia mater.

When the pineal body contains no distinct cavity, which is not unfrequently the case, the viscid fluid is distributed through it as through a sponge.

As to the nature of this body, it appears to consist of a soft grey substance,

* Ridley describes certain white striæ arising from the pineal body and terminating in the testes. Gall says that the inferior peduncles are directed backwards, and somewhat downwards, to become continuous with the subjacent white lamina. Plate xi. text, p. 223.

traversed by a great number of bloodvessels, having a very close resemblance to the grey matter of the brain, but none whatever to glandular tissues.

Concretions of the conarium. One of the most curious circumstances in regard to this body is the existence in it of certain hard concretions, which Ruysch and others regarded as small bones, an error which was successfully combatted by Soemmerring. The use of them is utterly unknown.

Are these concretions constant? The brothers Wenzel found them wanting in six brains out of one hundred. Soemmerring states that he found them in fifteen brains, among which were some of very young infants, and he adds that they exist in the fœtus before the full period. Meckel says they do not appear until the sixth or seventh year, beyond which age he always found them.

These concretions sometimes form a single mass (acervulus, *Soemmerring*) resembling a granular lump of salt; sometimes, and most commonly, there are a great number of them.

They appear as aggregated granules, which the Wenzels believed to be connected by means of a proper membrane.

Seat of the concretions. When the pineal body is hollow, they are found in its interior; but when it is solid they are situated upon the surface of this body. I have found them several times upon its peduncles.

They are of an opaline yellow colour in old subjects, and are whitish in the young. According to Pfaff, they consist of phosphate of lime, carbonate of lime, and an animal matter.

They were incorrectly regarded as morbid deposits by Morgagni, who supposed without proof that they might produce cerebral affections of greater or less severity.

Function of the pineal gland. The hypothesis of Descartes concerning the function of this body, which was so completely refuted by Steno, is a striking example of the abuse of an imperfect knowledge of anatomy; according to Descartes the soul is seated in the pineal gland, and it directs all the movements of the body by means of the peduncles, which he regarded as the gubernacula or reins of the soul. M. Magendie thinks that this body performs certain functions having reference to the cerebro-spinal fluid: he has regarded it as a kind of plug, which would obstruct the orifice of communication between the third and fourth ventricles; but in the first place, it is completely fixed by the pia mater, and in the second case, even if it were free, it could not in any case close the orifice alluded to. Morbid conditions of this body will perhaps throw some light upon its functions, but they have not yet been sufficiently studied. The existence of a cavity within the pineal gland, added to the fact that it is sometimes the seat of dropsy, would seem to indicate that its functions are connected with secretion.

The Lateral Ventricles.

Dissection. The lateral ventricles are exposed by the same dissection as that which we have pointed out for the examination of the fornix and septum lucidum, that is to say, by removing the upper parts of the hemispheres and dividing the corpus callosum on each side of the median line (as in *fig.* 278. on the left side). In order to trace the reflected portion or descending cornu it should be laid open, by cutting through its outer wall from behind forwards. There is also a great advantage in studying this part of the lateral ventricles from the base of the brain.

The *lateral ventricles* (*f i g h*, *fig.* 278.) are two in number; they are much larger than the other ventricles; are placed symmetrically one on each side of the median line; they are separated from each other, but communicate through the medium of the third ventricle; their upper part is nearer to the base of the brain than to its upper surface, and they approach still nearer to the base by their reflected portion or descending cornu.

Each lateral ventricle commences (*f*) in the substance of the anterior lobe (*a*) a little in front of the third ventricle, and behind the anterior reflected extremity of the corpus callosum (*e*) by which it is bounded in front; from this point it passes vertically upwards and backwards, describing a curve with its convexity directed inwards; having reached (*r*) opposite the posterior part of the third ventricle, it changes its direction, so as to turn downwards and forwards round the optic thalamus (*l*), and then terminates (*h*) in the substance of the sphenoidal portion of the posterior lobe [*i. e.* in the middle lobe] (*c*) behind the fissure of Sylvius, and consequently a little below and behind the point (*f*) at which it commences. At the point of its reflection it also sends a prolongation (*g*) backwards into the occipital portion of the posterior lobe (*b*). From this it will be understood why each lateral ventricle has been compared to a capital italic *£* turned upside down, and why the cavity is said to have three cornua, viz. an *anterior* or *frontal* (*f*), *an inferior*, *descending* or *sphenoidal* (*h*), and a *posterior* or *occipital cornu*, (*g*); on this account the lateral ventricles are frequently denominated *ventriculi tricornes.*

It is also seen, that the ventricles are applied to each other at their anterior extremities, but diverge behind like the limbs of the letter *x*.

The general form of the lateral ventricles is very well shown upon a longitudinal section of the cerebrum through the median line: each of these ventricles is then seen to be nothing more than an elliptical canal or passage, which runs around the large ellipsoid mass formed by the optic thalamus and corpus striatum. This elliptical canal is only interrupted below and in front opposite the fissure of Sylvius. Anatomists describe in each lateral ventricle a *superior portion*, an *inferior portion*, and a *posterior portion* or *digital cavity.*

The Superior Portion of the Lateral Ventricle.

This portion, called the body of the ventricle (*i*), is broader in front than behind, and presents for our consideration a superior, an inferior, and an internal wall.

The *superior wall* or the *roof* is formed by the *under surface of the corpus callosum.*

The *inferior wall* or the *floor* is formed by the *ventricular surfaces of the corpus striatum* (*i*) and *optic thalamus* (*l*); between these two bodies are found the *lamina cornea* and *tænia semicircularis* (*n*).

The corpus striatum. When examined from the lateral ventricle, each of the *corpora striata* (*i i*, *figs.* 278. 280.) appears like a pear-shaped or conoidal eminence, having its larger end turned forwards, and its other end, which is very narrow, prolonged backwards, into the reflected portion of the ventricle. Its grey colour contrasts with the whiteness of the surrounding parts. Its free surface is covered by the lining membrane of the ventricles, and is very regularly marked by certain large veins which run across it.

The ventricular surface of the corpus striatum forms only one portion of this body, which has received its name from the white bundles or striæ, which traverse the grey matter, of which it is principally composed.

The corpus striatum, considered as a whole, is an ovoid grey mass, lodged in a deep excavation formed opposite the *insula* or *island* of Reil, which is situated in the fissure of Sylvius, and which I propose to name the *lobule of the corpus striatum.* It will be seen hereafter, that the corpus striatum is covered on the outer side by the convolutions of the *insula*, that it corresponds on the inner side with the optic thalamus and the grey matter of the third ventricle, and that it is exposed below, at the back part of the anterior lobes of the brain, behind the convolutions which form the sides of the furrow for the olfactory nerve.

The *optic thalami* (*l l*, *fig.* 280.), which as we have already seen constitute the lateral walls of the third ventricle, form also, by their upper surface, a part (*l*, *fig.* 278.) of the floor of the corresponding lateral ventricle; this surface,

which is oblong from before backwards, commences about six lines from the anterior extremity of the lateral ventricle: it is covered by the choroid plexus (p) and the fornix (k): the corresponding anterior pillar of the fornix turns round its anterior extremity, and the interval between the pillar and the thalamus forms the opening of communication between the third and the corresponding lateral ventricle. The brownish white colour (*couleur café au lait*) of the optic thalamus distinguishes it from the corpus striatum, which lies along its outer side; the lamina cornea and the tænia semicircularis, marking the limits between these two bodies.

The *lamina cornea* is a thick, semitransparent band, of a horny aspect, which was compared by Tarin to a plate of horn, and which appears to be nothing more than a thickened portion of the lining membrane of the ventricle. Beneath and protected by it is found the *vein of the corpus striatum*, which receives the venous branches already described upon the surface of that body. Beneath the vein is seen a small, white, linear band (n), to which Willis first directed attention as the *limbus posterior*, and which is now called the *tænia semicircularis.*

I would observe that the lamina cornea and the tænia semicircularis are two very distinct structures, which most anatomists have erroneously confounded.

More deeply, the limits between the corpus striatum and optic thalamus are marked by a white layer, described by Vieussens as the *geminum centrum semicirculare*, or *double semicircular centre.*

The lateral portion of the fornix and the choroid plexus (see *fig.* 278.) must also be regarded as entering into the formation of the floor of the lateral ventricle. This lateral portion of the fornix resembles a band applied upon the optic thalamus, but separated from it by a fissure through which the choroid plexus becomes continuous with the velum interpositum*: the choroid plexus runs along the free edge of this band, and is sometimes turned up on to its upper surface.

The *internal wall* or *septum of the lateral ventricles* is much deeper in front, where it is formed by the *septum lucidum*, than behind, where it consists of a small vertical portion of the fornix, with which it terminates. We ought also to regard as forming a part of the septum of the lateral ventricles, a prolongation on each side of the grey matter of the third ventricle, which passes round the corresponding anterior pillar of the fornix, and upon the lower part of the septum lucidum.

The Inferior or Reflected Portion of the Lateral Ventricle.

Dissection. As the reflected portion or descending cornu belongs to the base of the brain, it is well to place the brain upon its convex surface, and then proceed to open it.

This cornu may also be reached from the great transverse fissure, by first removing the pia mater which enters there, and then partially dividing the lower wall of the cornu from the fissure of Sylvius backwards, and turning back the lower wall on itself.

The *descending cornu* (h, *fig.* 278.) *of the lateral ventricle* has two walls, a superior and an inferior. The superior wall (b, *fig.* 281.) is concave, and, being moulded upon the *pes hippocampi* or *cornu ammonis* (m), which forms the inferior wall, is named *the sheath of the pes hippocampi.*

Upon the inferior wall are found the *pes hippocampi* or *cornu ammonis*, the *corpus fimbriatum*, the *fascia dentata*, the *great cerebral fissure*, and the *reflected portion of the choroid plexus.*

The *cornu ammonis* or ram's horn, *pes hippocampi* †, or *foot of the sea horse,*

* [A comparison of *figs.* 278. and 279. will facilitate the comprehension of this statement; in the latter *fig.* the fornix is reflected backwards, and the continuity of the choroid plexus (p) with the velum (v) is shown.]

† [The term *pes hippocampi* is generally applied to the anterior part only of this structure, the whole being usually called hippocampus major.]

is a conoidal eminence (*m*, *fig.* 278.) * curved upon itself, and having its larger end turned forwards, and its small end backwards. Its concave border, which is directed inwards and forwards, is bounded by a narrow, thick, and dense band, which forms a continuation of the posterior pillar of the fornix; this is the *tænia hippocampi*, so improperly named the *corpus fimbriatum* or *fringed body* (*s*).

On raising up the tænia hippocampi (*s*, *fig.* 281.), there is seen beneath it a band of grey matter (*d*), which runs along the inner border of the cornu ammonis: this grey matter, which is as it were crenated by transverse furrows, has been well described by Vicq d'Azyr under the name of *corps godronné*, or *fascia dentata*.

Fig. 281.

To obtain an accurate idea of the cornu ammonis, it is necessary to examine vertical sections of it, as was done by Vicq d'Azyr, who has given very good figures of such sections: it is then seen (as in *fig.* 281.) that the hippocampus major (*m*) is formed by a reflection of the hemisphere inwards upon itself, as the brothers Wenzel have very well shown; and that it is composed of a convolution doubled or turned upon itself like a horn, so that the white convex part expands in the interior of the lateral ventricle, whilst the grey concave part is upon the surface of the cerebrum.†

The surface of a vertical section of the hippocampus major also presents a white spiral line (below *m*), which is the section of the white covering of this eminence, and a rather thick grey layer (*a*), which is subdivided into two smaller layers by a white streak (*c*); all these are arranged in a spiral manner.

The white layer which forms the covering of the cornu ammonis is continuous on the one hand with that which lines the rest of the lateral ventricle, and on the other (by means of the corpus fimbriatum, *s*) with the corpus callosum and the fornix. Not unfrequently a second pes hippocampi is found on the outer side of the first, to which it is concentric; it is called *pes accessorius* (*eminentia collateralis*). Meckel erroneously regards it as the result of an arrested developement.

The inferior wall of the descending portion of the lateral ventricle further presents for our consideration: —

The *reflected* or *descending portion of the choroid plexus* (see *fig.* 278.); and also the *great transverse fissure*, through which the choroid plexus becomes continuous (opposite *s*, *fig.* 281.) with the external pia mater: the lower border of this fissure is formed by the hippocampus major and corpus fimbriatum; and the upper border by the lower surface of the optic thalamus, which presents in this situation the *corpus geniculatum externum* (*j*, *fig.* 271.), an oblong eminence which is continuous with the optic tract, and the *corpus geniculatum internum* (*i*), a small rounded eminence, which is circumscribed by the corpus geniculatum externum.

* I have not found, like Treviranus, the medullary substance of the anterior extremity of the cornu ammonis either continuous or communicating in any manner with the external root of the olfactory nerve; I cannot, therefore, admit that the functions of the cornu ammonis have any relation with those of the nerves in question. Treviranus believes that it assists in the remembrance of olfactory impressions. It is unfortunate for this hypothesis, that the animal in which the cornu ammonis is most developed, viz. the hare, is precisely that in which there is least evidence of memory.

† I could never perfectly understand the structure of the cornu ammonis until I had examined it in ruminantia and rodentia, but especially in the latter, in which it is most developed. In the rodentia the reflected portion of the hemisphere is almost as large as the hemisphere itself; and the connexions of the cornu ammonis with the fornix are seen most distinctly. It is quite evident that the fornix, the cornu ammonis, and the corpus fimbriatum, form only one system of fibres and are continuous with each other.

The Posterior Portion of the Lateral Ventricle.

The *digital* or *ancyroid cavity* (ἄγκυρα, a hook) is the occipital portion (*g*, *fig.* 278.) of the lateral ventricle. The term digital cavity has arisen from its having been compared to the impression which the finger would leave if pushed backwards into the substance of the brain. It commences at the point where the ventricle is reflected upon itself, passes horizontally backwards describing a curve with the convexity turned outwards, and becomes gradually narrower until it terminates in a point. The dimensions of this cavity are extremely variable, not only in different individuals but even in the same subject. Thus, a very large digital cavity is often found on the right side, while on the left there is only a trace of it.

Acute ventricular hydrocephalus affects the digital cavity more than any other part of the ventricle.* In some cases the bottom of the digital cavity is not more than half a line from the surface of the brain.

In the natural state, the upper wall of the digital cavity is exactly fitted to a conoidal eminence, which occupies the lower wall or the floor of that cavity, and which differs in its dimensions according to the size of the cavity itself. This eminence (*n*), which is variously named the *unciform eminence*, *colliculus*, *calcar*, *unguis*, was very well described by Morand † under the name of the *ergot*, and is therefore generally called the *ergot of Morand*.

In form it rather closely resembles the hippocampus major, so that we ought perhaps to prefer with Vicq d'Azyr the name of *hippocampus minor*. There is not only a correspondence in form, but also in structure, between the two hippocampi; and the brothers Wenzel appear to me to have clearly shown that the ergot of Morand, like the hippocampus major, is nothing more than a special convolution projecting into the ventricle. It in fact consists of a white layer inclosing a thick mass of grey substance. A longitudinal anfractuosity, the depth of which depends on the prominence of the ergot, denotes on the surface of the brain the situation of the digital cavity: this anfractuosity is constant, and I have already described it as the *anfractuosity of the digital cavity*. There is also another circumstance which favours the analogy between the ergot and the hippocampus major, and that is their continuity; for there is only a depression between them, and the white layer which connects them is continuous in both cases with the fornix.

Gredins has described several varieties of the ergot; not unfrequently it is double, and as we have mentioned so is the hippocampus major. The absence of the ergot is regarded by Tiedemann as the result of defective developement.

The ergot and the digital cavity scarcely exist except in man, doubtless because he alone has the occipital portion of the brain greatly developed.

The Choroid Plexuses.

The *choroid plexuses of the brain*, which have already been noticed in the descriptions of the third and lateral ventricles, form a continuous system of vessels, as can be easily shown by examining the brain from the base upwards. Upon the under surface of the velum interpositum, and on each side of the median line, are two small, red, granular bands, running from behind forwards, bordered by the veins of the corpora striata, and terminating in front upon the convexity of an arch which forms the boundary of the velum in that direction. This arch is formed by the junction of the anterior extremities of the choroid plexuses. It is situated behind the anterior pillars of the fornix, at the point where those pillars unite, and is crossed at right angles

* It is probable that this is simply the mechanical effect of long continued lying upon the back.

† Mem. de l'Acad. des Sciences, 1744. Observ. Anatomiques sur Quelques Parties du Cerveau.

by the veins of the corpus striatum, which pass above it; after this junction, the choroid plexuses again separate and enter the lateral ventricles through the foramen (foramen of Monro) which leads from the third to the lateral ventricles; within each of the lateral ventricles they describe an elliptical curve (*p*, *fig.* 278.), which is accurately moulded upon the optic thalamus, and runs along the fornix in the upper part of the ventricle, and along the corpus fimbriatum in the descending cornu or reflected portion.

The upper part of the choroid plexus is very narrow; the lower part is three or four times broader than the upper; its upper and under surfaces are free, and also its outer border, which contains a large vessel; its inner border is continuous with the velum interpositum * in the upper part of the lateral ventricle, and in the descending cornu with the pia mater at the base of the brain.

The lining membrane of the ventricle adheres intimately to the inner border of each choroid plexus, so that the lateral ventricles are completely closed, and no fluid can escape through the semicircular fissure which extends along their entire course.

The choroid plexuses are granular, or rather consist of vascular tufts which are unlike any other structure in the body, and their uses are quite unknown.

The Lining Membrane, and the Fluid of the Ventricles.

The middle and lateral ventricles are lined by a transparent and tolerably strong membrane, of which the horny lamina between the corpus striatum and thalamus opticus is a part. On tracing this membrane from the third ventricle, it is seen to pass into the lateral ventricles through the foramen (of Monro) behind the anterior pillar of the fornix. From the third ventricle it also descends into the fourth through the aqueduct of Sylvius.

It is extremely easy to demonstrate this membrane, especially upon the septum lucidum and corpora striata, and in the digital cavities.

In order to separate it to any extent, it must be dissected from without, by gradually removing the layers of cerebral substance by which it is covered. This separation occurs in acute ventricular hydrocephalus in consequence of the pultaceous softening of the surrounding tissue. In the fœtus and new-born infant, this membrane can be separated with the greatest facility, on account of its density and the softness of the surrounding parts.

Three questions present themselves regarding the ventricular membrane: Is it a serous membrane? Does it communicate with the arachnoid, so that it ought to be regarded as a continuation of that membrane? How is it arranged along the fissure of each lateral ventricle?

That the ventricular membrane is a serous membrane is shown by the nature of the fluid exhaled into the cavity of the ventricles; by the structure of the membrane itself, which consists entirely of lymphatic cellular tissue; and by the diseases of the ventricles, which are precisely similar to those of other serous cavities.†

The number of veins which are situated beneath the ventricular membrane has suggested the notion that it was a prolongation or continuation of the pia mater: but these vessels do not belong to the membrane.

The continuity of the ventricular membrane with the arachnoid on the surface of the brain has not been demonstrated. I have already said that the so-called canal of Bichat does not exist.

It has been stated that each lateral ventricle is divided, both in its direct and reflected portions, by a circular fissure which turns round the optic thalamus, and through which the pia mater becomes continuous with the choroid plexus. This fissure is closed by bloodvessels, and some very dense cellular tissue, and in the interior of the ventricle by the lining membrane, which is

* Compare *figs.* 278 and 279.

† The occurrence of acute and chronic serous effusions, of purulent formations, and of miliary granulations in the ventricles, are proofs of the serous nature of their lining membrane. [The ventricular membrane has a ciliated epithelium on its inner surface.]

firmly attached on both sides of the fissure to the adherent borders of the corresponding choroid plexus. It cannot be admitted that it passes from one side of the fissure to the other so as to inclose the plexus.

It is this membrane which prevents any fluid contained in the ventricles from infiltrating into the sub-arachnoid cellular tissue at the base of the brain.

The very frequent coincidence of ventricular dropsy with the formation of false membrane in the cellular tissue at the base of the brain shows the relation between that tissue and the lining membrane of the ventricles, but by no means establishes the existence of any direct communication between the ventricular cavities and the cellular tissue at the base of the brain.

The ventricular fluid. The existence of a serous fluid in the ventricles was generally admitted by the older anatomists, who named it *pituita*, and considered it to be an excrementitious fluid, which was evacuated through the nasal fossæ. During the last century, anatomists were so convinced of its existence in all subjects, that they regarded those cases in which it was not found as exceptions; *a recentissimis cadaveribus abest nonnunquam*, says Haller, in speaking of an observation made by Verduc upon the brain after death by decapitation. But the anatomists of the last century differed from the ancients, in regarding the existence of fluid in the ventricles as a post-mortem phenomenon, depending on the condensation, by cold, of a vapour which in their opinion alone exists in the ventricles during life. This vapour, the only use of which, according to the view stated, would be to prevent adhesion of the opposite walls of the ventricles, was compared by them to that which is found in the pleura, pericardium, and peritoneum of a living animal.

The experiments of M. Magendie have proved the existence of a ventricular fluid during life; and further, that it may flow backwards and forwards into the spinal sub-arachnoid space, through the opening (*y*, *fig.* 282.) in the lower part of the fourth ventricle.

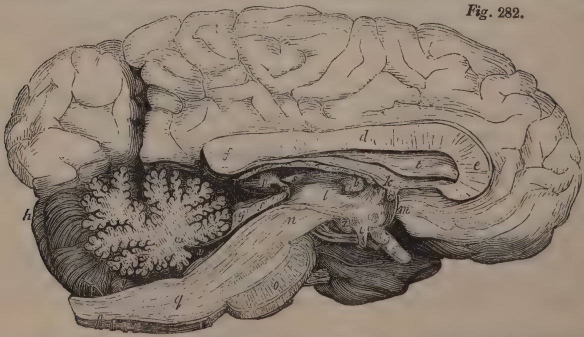
The quantity of fluid in the several spaces found in the cranial cavity is extremely variable, for it increases or diminishes according to the relative bulk of the brain in reference to the osseous case of the skull.

Having thus examined the brain by horizontal sections made at different heights from the convex surface towards the base, it is important, in order thoroughly to understand the parts we have described, to study them under different aspects, either by means of particular sections, or by the aid of the various methods adopted by different anatomists.

A Median Vertical Section of the Brain.

Upon this section (*fig.* 282.), which divides the brain into two perfectly

Fig. 282.



similar halves, a great many objects are seen: and first, the optic thalamus and corpus striatum, which might be said to form the central nucleus or root of the cerebrum.

The optic thalamus is now seen to be smooth and free on its inner surface, where it forms the lateral wall (l) of the third ventricle; it is convex and free above, where it forms part of the floor of the lateral ventricle, and it is also free below, where it presents to our notice the corpora geniculata. Behind, it is continuous with the tubercula quadrigemina, and in front with the corpus striatum; on the outer side it is blended with the corresponding cerebral hemisphere, and below it is deeply notched for the reception of the corresponding cerebral peduncle.

The corpus striatum forms a concentric curve along the outer side of the optic thalamus; it commences in front by a large pyriform extremity, diminishes in size as it proceeds backwards, and terminates in a very narrow grey band which turns round the optic thalamus as far as the termination of the descending cornu of the lateral ventricle, *i. e.* as far as the large end of the cornu ammonis.

The lateral ventricle forms a circular or elliptical trench around this central nucleus formed by the thalamus opticus and corpus striatum (see *fig.* 278.). It commences in the substance of the anterior lobe of the cerebrum (*anterior* or *frontal cornu*), mounts up upon the corpus striatum, passes horizontally backwards, and becoming widened divides into two prolongations, one horizontal (*digital cavity*, *occipital* or *posterior cornu*), which dips into the substance of the posterior lobe and terminates near the surface of the brain; the other reflected, which runs from behind forwards, and terminates behind the fissure of Sylvius, so that the lateral ventricle would describe an almost complete ellipse if it were not for the layer of cerebral substance which forms the bottom of the fissure of Sylvius, and which separates the commencement (f) from the termination (h) of the ventricle.

Upon the longitudinal section is also seen the regular curve of the corpus callosum (*e d f*, *fig.* 282.), which runs around the central nucleus. The unequal thickness of the different parts of the corpus callosum, its reflection in front so as to embrace the anterior extremity of the corpus striatum, its posterior enlarged extremity or protuberance, and its continuity with the fornix, are shown: and further it is seen that the space between the corpus callosum and the central nucleus of the brain constitutes the upper part of the lateral ventricle, and that the interval between the cornu ammonis and the nucleus constitutes its reflected portion.

In this section we also notice the septum lucidum (t), the fornix (k), the mammillary tubercle (z), the tuber cinereum, the grey commissure (b) and grey mass of the third ventricle, the infundibulum (i), the optic nerve (2), the section of the anterior commissure (c), also that of the posterior commissure (x), and the peduncle (s) of the pineal gland (p).

The longitudinal section also shows that the third ventricle is formed by the juxtaposition of the two central nuclei of the cerebral hemispheres; that these hemispheres are only connected to each other by the corpus callosum and the commissures, and therefore that it is by studying these parts that the system of communicating fibres between the two hemispheres is displayed.

It is moreover seen that each hemisphere may be regarded as composed of a white and grey covering which surrounds a central nucleus. And it is between the general central nucleus and the hemispheres, or rather between the fornix and its prolongations on the one hand and the optic thalami on the other (as at s, *fig.* 281., for example), that the ventricles would communicate with the exterior if the ventricular membrane were not firmly attached to the choroid plexus: it is also in the same situation that the external pia mater passes into the internal.

The central nucleus. A very curious preparation may be very easily made upon this vertical median section, to show the central nucleus separated from the other parts. If the handle of a scalpel be introduced between the corpus striatum and the reflected portion of the corpus callosum, it will be found that the ventricular membrane is the only means of connexion between them, and

that the corpus callosum forms at this point a sort of outer case of medullary substance for the corpus striatum, the entire anterior portion of which may be exposed without breaking through any connecting fibres. The anterior part of the corpus striatum may also be exposed from below, that is to say, by dissecting from the base of the anterior lobe of the cerebrum towards the lateral ventricle; for this purpose the handle of the scalpel must be inserted along a curved whitish line, the concavity of which is turned forwards, and which limits the anterior lobe behind.

The corpus striatum can be completely isolated only in front and opposite the fissure of Sylvius, in which situation it is covered by only a slight thickness of cerebral substance, which is seen to consist of four very distinct layers, viz. the external grey layer of the convolutions; a very thin white layer; an equally thin grey layer; and lastly another layer of medullary substance.

Transverse Vertical Sections.

I am in the practice of making five transverse sections of the cerebrum: the first, immediately in front of the corpus callosum; a second through the largest part of the corpora striata; a third through the anterior part of the optic thalami; a fourth through the middle of the thalami; and a fifth through the occipital portion of the posterior lobes. I shall not here enter into a detailed description of these several sections, which appear to me to convey a more correct idea of the structure of the brain than any other sections, but which cannot be well understood without figures. They disclose in fact a medullary centre giving off three or four prolongations of white substance, which constitute in their turn the medullary centres of a certain number of convolutions to which they are distributed; this ramified disposition of the medullary substance warrants the application of the term *arbor vitæ of the cerebrum* to the appearances seen upon these different sections.

The most interesting of these sections is undoubtedly that which passes through the cerebral peduncles, and which discloses the following appearances: —

Each hemisphere is formed by a medullary centre, which gives off three principal prolongations around which all the convolutions are arranged, and are thus collected into three groups, viz. a superior, an external, and an inferior group; the last of these is connected with the medullary centre by a long narrow pedicle, which corresponds to the white matter on the outside of the corpus striatum. The corpus striatum and optic thalamus are situated opposite to this pedicle or prolongation of the medullary centre.

The medullary centres of the two hemispheres are connected together by the corpus callosum, which forms an arch with the concavity directed downwards. Moreover, either the section of the septum lucidum, or of the fornix, is seen according to the point at which the knife has been carried through.

The transverse section through the corpora striata and optic thalami deserves special attention. If the section be made through the anterior part of the corpus striatum, and therefore in front of the optic thalamus, the former body presents an oval grey surface, dotted with white points, which are sections of medullary fibres; the middle of this oval surface is traversed by a series of small, parallel, white fasciculi, which are sections of the medullary bands that pass through the corpus striatum. On the outer side of the corpus striatum are seen distinctly the four layers formerly mentioned as corresponding to the island of Reil. The white layer which turns round the outer surface of the corpus striatum may be said to be reflected upwards to form the septum lucidum.

Several of these sections appear to me to show that certain white fibres, which arise in the interior of the corpora striata, pass to the circumference of the optic thalami, or it may be said that certain white fibres arise in the optic thalami, spread out, and are lost in the substance of the corpora striata,

beyond which it is impossible to trace them. This beautiful section suggested to M. Foville * some ideas respecting the structure of the brain, to which I shall presently have occasion to refer.

The Section of Willis.

Previously to the time of Varolius and Willis, anatomists were contented with making successive horizontal sections of the brain from the vertex towards the base, and studying minutely the parts thus exposed; and each anatomist believed that he had described different objects, when chance presented him with some arrangement that had not been previously described. Willis insisted upon the necessity of carefully removing the membranes from the surface of the brain, and he objected to the usual method of examining this organ by making sections, which destroy the connexions between its different parts; he considered the brain to be composed of *parts folded* upon themselves, collected into a globular form, and connected to each other by mutual prolongations. He also pointed out the importance of first examining the brains of animals, which are much more simple than the brain of man, the size and complexity of which render its study one of great difficulty.

After having made these judicious remarks, Willis proceeds to describe the following mode of making the section which he had contrived, for the purpose of unfolding the cerebrum and opening out this spheroidal mass into a flat surface †: —

Place the brain, completely stripped of its membranes, upon its convex surface; turn forwards the cerebellum and the medulla oblongata; introduce the knife into the fissure of Sylvius, and carry it backwards as far as the digital cavity; a flap will thus be detached, comprising all the lower wall of the descending cornu of the lateral ventricle. Repeat this section on the opposite side; and, after having turned backwards the flaps thus formed, another section must be made on each side of the brain, extending from behind forwards along the corpus striatum, on a level with the outer border of the corpus callosum, and reaching to the anterior extremity of the lateral ventricle. Turn forwards the intermediate flap, which will comprise the cerebellum, the pons Varolii and peduncles, the optic thalami, and the corpora striata.

The whole of the interior of the ventricle is thus exposed, so that we can examine the lower surface of the corpus callosum, and its continuity with the centrum ovale of each hemisphere, or the centrum ovale of Vieussens seen from below. The continuity of the fornix with the cornu ammonis is also well displayed. ‡

General Remarks upon the Method of examining the Brain by successive Sections.

The method of examining the brain by successive sections has been carried farthest by Vicq d'Azyr, whose beautiful plates are entirely devoted to the demonstration of the objects seen upon various sections of the brain made in succession either from below or from above. This method unfolds to us the relative disposition of the grey and white substances, shows the manner in which the ventricles are formed, and displays to us the real nature of parts

* Note sur la Structure du Cerveau, 24e Bulletin de la Société Anatomique. (*Nouvelle Bibliothèque Médicale.*)

† The brains of animals, being much less complicated than that of man, are more convenient for this purpose. The brain of a sheep thus unfolded is represented by Willis in his *Cerebri Anatome*, Fig. VII.

‡ This section, which however, like all similar methods, is liable to the objection that it destroys the connexion of parts, suggested to M. Laurencet the idea of comparing the cerebral mass to a nervous loop, analogous to the loops described by MM. Prevost and Dumas as forming the terminations of the nerves. According to this view, the nervous system would represent an elongated ellipse, one end of which would be represented by the brain and the other by the extremities of all the nerves; but both loops are equally inadmissible.

which, in consequence of their projecting and being free at some part of their surface, have received particular names.

But this mode of examining the brain can only be regarded as a preliminary means calculated to give an idea of this organ as a whole. And it tends to perpetuate the erroneous opinion that the brain is a pulpy mass, consisting of a semi-fluid substance, and displaying no more evidence of contrivance in its structure than a ball of wax.

The method adopted by Varolius and Vieussens, which fell into disuse after the publication of the beautiful work of Vicq d'Azyr, and which consisted in determining the connexion of the different parts of the brain, has been revived and improved by Gall and Spurzheim, who have thus opened up the path which modern anatomists have so eagerly pursued.

Methods of Varolius, of Vieussens, and of Gall, or the Examination of the Connexions of the Different Parts of the Brain.

Varolius was the first to perceive that the essential point in the study of the brain was to ascertain the connexion of its several parts. He was also the first who dissected the brain from below, and who specially examined its connexion with the spinal cord; he described the spinal cord as originating from the brain, not opposite the foramen magnum, but from the lower part of the cerebral ventricles.

Vieussens traced the bundles of the pyramids through the pons Varolii to the peduncles of the brain, and followed these peduncles through the optic thalami and the corpora striata into the centrum ovale, which is named after him. But there his inquiries ended, for according to him it was in this centre that the linear or radiated structure terminated: and his preconceived notion of a nervous centre (centrum ovale), from which with Varolius he described all the fibres as proceeding downwards, prevented him from carrying his researches farther.

Gall followed up the investigations of Varolius and Vieussens, but instead of dissecting the fibres from above downwards, or from the brain towards the medulla, he traced them from below upwards, or from the medulla towards the brain, and followed them through the centrum ovale as far as the convolutions.

The method adopted by Gall in order to separate the fibres of the cerebrum and show their connexions, was to scrape them with the handle of a scalpel. But from the nature of this proceeding, only those white fibres can be conveniently traced which pass through grey matter, but the white fibres themselves can never be separated from each other. Hardening the brain in strong alcohol, in nitric or muriatic acid, or by boiling it in oil, or by macerating, or boiling it in a solution of salt, facilitates the separation of its fibres; but, as the results obtained in these modes might be considered as purely artificial, the action of a stream of water is preferable to any of them.

The results obtained by acting on the brain by streams of water fully confirm those which are arrived at by the examination of the hardened brain.

Again, the anatomy of the fœtal brain and comparative anatomy have also aided in throwing light upon the connexion between the different parts of the brain.

As the works of Gall were the commencement, if not the foundation, of all that has since been done, I have thought it necessary to give a brief summary of his views regarding the structure of the brain; and as a knowledge of its structure consists in a great measure in that of its connexions with the cerebellum and spinal cord, the examination of these two subjects cannot properly be separated.

Gall and Spurzheim's Views of the Structure of the Brain.

Gall and Spurzheim commence by stating, 1. That as the brain consists of several departments, the functions of which are totally different, there are several primitive fasciculi, which by their developement assist in the formation of that organ. 2. That these fasciculi are composed of medullary fibres arising successively from the grey matter, which, with Vicq d'Azyr, they regard as the matrix or generator of the white substance. 3. That there exist in the brain a formative system of fibres, or a formative apparatus, and systems of uniting fibres, called commissures. In the first or formative system, Gall describes four primitive fasciculi; namely, the anterior pyramids, the posterior pyramids, the olivary fasciculi, the longitudinal fasciculi, which assist in forming the fourth ventricle, and some others which are yet imperfectly understood.*

Formative system of fibres. The anterior pyramidal fasciculi decussate at their origin; but the other fasciculi arise on the same side as the hemisphere to which they belong.

The anterior pyramidal fasciculi (*b′*, *figs.* 273, 274.) are reinforced as they pass through the pons Varolii (*m*), which is therefore, according to Gall's view, a ganglion, named by him the ganglion of the anterior pyramidal fasciculi; these pyramidal fasciculi constitute the cerebral peduncles (*x*, *fig.* 283.), and diverge (*y y′*), so as to enter the inferior, anterior, and external (*i* and *m*, *fig.* 284.) convolutions of the anterior and middle lobes.

Gall, in his beautiful plate No. V., shows the expansion of the fibres of the peduncles, their distribution, their unequal lengths, and the manner in which their expanded extremities are covered with grey matter to form the convolutions.

It still remains to determine how the superior convolutions and those of the posterior lobe are formed: the following are the statements of Gall on this point: —

The olivary bodies of the medulla oblongata are nothing more than ganglia from each of which a very strong bundle, the *olivary fasciculus* (see p. 943.), emerges, and ascending behind the pons, where it is considerably reinforced, passes through the grey matter which lies upon the white fibres of the cerebral peduncle, where it again receives some additional fibres; this grey matter constitutes a rather firm ganglion on each side; these are the *optic thalami*, which, according to Gall, do not assist in the formation of the optic nerves and bear no proportion to them in size.

The olivary fasciculi, which are divided into very delicate filaments in traversing the optic thalamus, are again collected together as they emerge from its upper border. They then pass through a thick mass of grey matter, the *corpus striatum*, half of which projects into the ventricular cavity, whilst the other half is surrounded by the convolutions of the island of Reil. The radiated fasciculi (*k*, *fig.* 284.) are again reinforced in traversing the corpus striatum, which is regarded by Gall as another ganglion, and are then sufficient to form all the posterior convolutions, and also those which are situated along the upper border of each hemisphere, in the median line (*h h h*).

It therefore follows, according to Gall, that the convolutions are nothing more than the perfecting of all the preceding structures, which should be regarded as preparatory systems of fibres destined to form a whole.

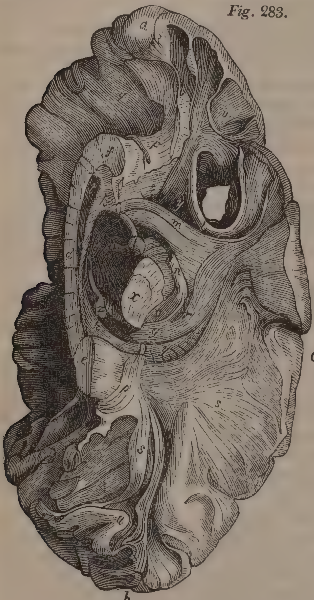
Uniting system of fibres or commissures. Even the oldest anatomists regarded the corpus callosum as the connecting medium between the two hemispheres; Vicq d'Azyr, who described several other commissures besides the

* It will be observed that Gall's fundamental statements are hypothetical: that the brain is developed from certain primitive fasciculi, that there is a successive increase of these fasciculi from below upwards, and that the grey substance is the matrix of the white, are so many suppositions. Of the primitive fasciculi, the anterior pyramids alone are well defined; the inaccuracy in the representation of the posterior pyramids disfigures his sixth plate.

corpus callosum, regarded them as intended to establish sympathetic connexions between the different parts of the brain. Gall, taking a more comprehensive view of this subject, attempted to determine what parts of the brain were connected by this means, and to discover the general law which governs the arrangement of the commissures, which he believed to be formed by a system of fibres and bundles, named by him *faisceaux rentrans ou convergens.*

We have seen that Gall traces the pyramidal and olivary fasciculi to the grey matter of the convolutions. According to him all the extremities of the medullary fibres penetrate the grey matter, which is therefore whiter internally than on the surface. Gall acknowledges that he has not been able to determine their ultimate distribution; he *does not know* whether they terminate in the grey matter or turn back again towards the interior. Nevertheless, he considers it *very probable* that new medullary filaments originate in this grey layer, and that there is thus *produced a system of fibres which reinforces the preceding* one, and is connected with it internally. *

Fig. 283.



According to Gall the commissures are, the *corpus callosum*, the *fornix*, and the *anterior* and *posterior commissures.*

The corpus callosum (*f d e*, *fig.* 283.) is intended to unite the convolutions of the two hemispheres. Its anterior reflected portion unites the inferior convolutions of the two anterior lobes (*f p a a*). The enlarged posterior extremity (*e*) receives the fibres (*s s*) of the posterior convolutions (*b*) and the middle portion of those of the middle convolutions (*c*).

The anterior commissure, which can be so easily traced (*m*) through the corpus striatum into the convolution of the sphenoidal extremity of the posterior [middle] lobe, is regarded by Gall as the means of connecting certain corresponding convolutions in the sphenoidal portions of the two posterior [middle] lobes.

The posterior commissure, which is lost in the substance of the optic thalami, and which is much smaller than the anterior, fulfils the same purpose for those bodies.

The posterior pillars (*k*) of the fornix are regarded by Gall as forming a commissure for the posterior convolutions of the two middle lobes. The fornix appears to him to result from the connexion of these parts, and he considers the interlacement called the *lyra*, to be composed of the connecting filaments. His error here is evident, for the fornix results from the juxtaposition of two medullary cords. The fornix may be regarded as an antero-posterior (*h k*), but not as a transverse commissure.

* Nothing certain appears likely to arise from this proposition, and yet Gall immediately adds (p. 202.), "It is certain that the existence of two systems of fibres in the brain can be distinctly demonstrated, and that the converging system contains more fibres and stronger fasciculi than the radiating system." On seeking for his proofs, we find that he infers that converging fibres must necessarily exist, from the disproportion between the white matter of the hemispheres and the fibres which come to them from the fasciculi of origin. "The converging fibres," says he, "at the bottom of all the convolutions are seen to enter between the diverging fibres, and interlace with them." It is very evident, from an examination of the proofs adduced by Gall in support of the existence of converging fibres, that the distinction between the converging and diverging fibres is purely hypothetical.

The ventricles and convolutions. The formation of ventricles is considered by Gall to be the *necessary* result of the divergence of some fasciculi and the convergence of others.

His description of the convolutions is entirely new, and one cannot but regret that it should be disfigured by the hypothesis of converging and diverging fibres. The following is his mode of describing these parts, which he regards as the completion and final object of the organisation of the brain, and as performing the most elevated functions.

Gall admits two layers in each convolution; and he finds that these two layers can always be readily separated, *but only* in the median line. He successfully proves, in opposition to the commission of the Institute, that the convolutions are not composed of a white, soft, and pulpy matter resembling pommade or jelly, but that they have a fibrous or linear structure. *

Unfolding of the cerebrum. The idea of unfolding the brain, which is nothing more than opening out the convolutions, was derived by Gall from his view of the structure of the convolutions, which he regarded as formed of two layers united by very delicate cellular tissue. It was also suggested to him by the examination of hydrocephalic brains, in which he conceived there was no disorganisation but merely an unfolding of the convolutions. The following is his method of unfolding the brain:— after having very carefully removed the meninges, he introduced his fingers into the great transverse fissure between the optic thalamus and the hippocampus major, and thus penetrated into the lateral ventricles: he then pressed gently against the outside of the ventricles; he broke down the white matter of the hemispheres, until he reached the base of the convolutions, which then necessarily became unfolded, so as to be moulded upon the back of his hand; the astonished spectators would have wondered less if they had seen the lacerations necessary to produce this result.

The unfolding of the brain is impossible, if Gall's views be correct; for, according to him, the white fibres of the brain are not all of equal length, and those which correspond to the anfractuosities are much shorter than those corresponding to the convolutions; besides, I am convinced, that, in hydrocephalus, the convolutions are not unfolded, but are atrophied, flattened, and compressed against each other.

Such are the principal ideas of Gall regarding the structure of the brain.† His system undoubtedly contains numerous errors and imperfections; but, nevertheless, it has established a new era in the study of the anatomy of this organ.

General Idea of the Brain.

1. The decussation of the pyramidal fasciculi of the medulla oblongata, their passage through the pons Varolii, their continuity with the cerebral peduncles, of which they form the lower portion, their passage through the optic thalamus, and their expansion within the corpora striata (*k*, *fig.* 284.), through which they may be traced (*h h h*) as far as the convolutions, are incontestable facts.

2. Again: it is no less certain that the fasciculi of reinforcement of the

* See note, p. 1011.

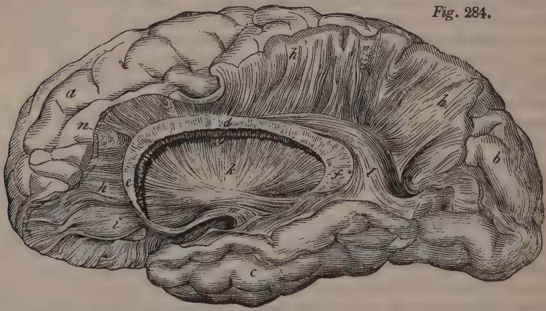
† The following is the completion of these ideas:— 1. As the peripheral extremities of the nerves expand in all the organs of our body to form an immense surface (and of this expansion the retina is an excellent example), so do the primitive fasciculi of the brain, after being reinforced in their passage through the different masses of grey substance, finally expand in the convolutions and receive a covering of grey matter. 2. There are as many particular systems as there are different functions, but they are all connected together by anastomoses. 3. The nervous system is double, but is united into one whole by the commissures. 4. There is not and there cannot be any common centre of all the sensations, thoughts, and volitions. 5. Personal unity will always remain a mystery.

Each of these propositions might form the subject of ample commentary. I will merely remark the incongruity between the acknowledged fact of personal unity, and the singular proposition that there neither is nor can be any common centre of all the sensations, thoughts, and volitions.

medulla are prolonged above the pons into the cerebral peduncles, of which they form the upper portion (*x*, *fig.* 283.), and become continuous, without any line of demarcation, with the optic thalamus. Do these fasciculi decussate? They remain distinct until they reach opposite the pons, behind the tubercula quadrigemina, where they unite; they appear to me to decussate, but not so evidently as the anterior pyramids, and I cannot venture to state this positively.

3. Fasciculi of white fibres radiate in all directions (*y y′*, *fig.* 283.) from

Fig. 284.



every part of the surface of the optic thalamus (*g g*), excepting its inner side, which is free, and corresponds to the third ventricle; the anterior of these fibres pass directly forwards, the middle fibres outwards, and the posterior fibres backwards, forming the radiating crown of Reil (*k*, *fig.* 284.).

As these radiating fibres emerge from the optic thalamus, they are bound down, as it were, by certain white curved fibres which constitute the tænia semicircularis.

4. *All the white fasciculi of the corpora striata*, excepting those which are continuous with the anterior pyramids, proceed from the optic thalami. Some of them appear to me to terminate in the corpora striata in the form of extremely delicate filaments, but the greater number pass through the corpora striata without either increase or diminution, and then pass into the hemispheres. The corpora striata of Willis are, therefore, nothing more than grey pulpy masses, which are traversed both by the white fibres radiating from the circumference of the optic thalami and by those which are derived from the anterior pyramids. The grey matter is not arranged in alternate linear striæ with the white substance. So far from thinking with Reil, Gall, and Tiedemann, that the fibres which emerge from the corpora striata are much more numerous than those which enter it, I have been led to a precisely opposite conclusion; namely, that a certain number of fibres, proceeding from the optic thalami, terminate in the interior of the corpora striata, the grey matter of which, in reference to these fibres, represents the grey substance in the convolutions.

5. From the anatomical fact that a certain number of white fibres terminate in the corpora striata, and also from the size of those bodies being in some animals inversely proportioned to that of the hemispheres, it appears to me to follow that the corpora striata may be regarded as internal convolutions, in which a certain number of medullary fibres terminate.*

6. It is extremely easy, by means of a stream of water, to separate, and as it were enucleate, the corpus striatum from the sort of shell formed for it by the cerebrum opposite the fissure of Sylvius. The corpus striatum is only

* In several cases of chronic hydrocephalus, in which the hemispheres were reduced to a very thin lamina, I have found the optic thalami atrophied and the corpora striata of enormous size.

connected with the cerebrum by the radiating fibres which emerge from its upper circumference near the corpus callosum.

The optic thalamus and its fasciculus of origin present no trace of a linear structure. Nor can we discover in it the concentric layers admitted by Herbert Mayo. With a little attention, certain extremely delicate white filaments are seen in the optic thalamus, which cannot be separated on account of their tenuity and the adhesion of the surrounding tissue to them. If the term *ganglion* be applicable to any part of the cerebrum, it certainly is so to the optic thalamus; for a nervous ganglion is nothing more than a peculiar apparatus in which nervous filaments become separated and spread out, in order to enter into new combinations. We must agree with Reil and Tiedemann in regarding the optic thalami as appendages of the cerebral peduncles: Tiedemann calls them the *enlargements of the cerebral peduncles.*

7. The essential points to be made out in the structure of the cerebrum are the ultimate course of the fibres radiating from the optic thalami and corpora striata, and the relations of those fibres with the convolutions of the brain and the corpus callosum. I by no means agree with Reil in thinking that we must not attach so much importance to the continuity of fibres in the cerebrum, and that their contiguity is a sufficient guide to its anatomy: on the contrary, I regard the determination of their continuity as the key to the structure of this organ.

8. There is no median raphé in the corpus callosum: the right half of its transverse fasciculi being continued into the left half without any line of demarcation.

9. It appears, at first sight, that the fibres of the corpus callosum (*e d f*, *fig.* 284.), and the white radiating fibres (*k*), which emerge from the optic thalami and corpora striata, decussate (as at *g*); but on separating the fibres of the cerebrum, either after it has been hardened in alcohol or by the action of a stream of water, it is most distinctly shown that these two sets of fibres are continuous.

10. Again: the continuity of the fibres of the corpus callosum with those of the hemispheres is no less evident; the middle fibres (*s*, *fig.* 283.) of the hemispheres are seen to pass transversely inwards, the anterior fibres (*a p*) backwards, the posterior fibres (*s*) forwards, and the inferior fibres to bend and turn upwards to become continuous with the corpus callosum.

I have in vain endeavoured to determine by actual dissection whether there is a decussation of the fibres of the corpus callosum itself; I still entertain many doubts regarding this subject; we shall presently find, when speaking of the developement of the brain, that the corpus callosum does not appear until after the hemispheres; and that comparative anatomy, by showing that the corpus callosum does not exist in the three lower classes of vertebrate animals, is opposed to the idea that the hemispheres are composed of certain fibres which decussate in the corpus callosum.

11. The doctrine of converging and diverging fibres, advanced by Gall and Reil *, cannot explain the continuity of the fibres of the corpus callosum with the radiating fibres of the corpora striata and optic thalami.

Tiedemann, from his researches into the anatomy of the fœtal brain, states that the corpus callosum is formed by the reunion of the fibres of the cerebral peduncles after they have expanded to form the hemispheres. He says that he has traced the fibres of the peduncles as far as the median line of the corpus callosum, where those of one side unite and are blended with those of the other; but a careful examination of the cerebrum, either by means of a stream of water, or by hardening it, shows that the fibres of the corpus callosum ter-

* The following is Reil's statement on this subject: — "Both of these two systems of fibres spread out into rays and meet each other; the cerebral peduncles ascend from below, and expand into the form of an inverted cone; the system of the corpus callosum, on the contrary, comes from above, and its fibres insinuate themselves between the preceding ones (see *g*, *fig.* 284.), and form, as it were, the lid of the cup.

minate in the convolutions, without presenting any sort of reflection, or forming any median raphé.

12. The dissections of M. Foville seem to establish the continuity of the corpus callosum both with the radiating fibres of the corpora striata and with the fibres of the hemispheres. According to his dissections, which consist essentially in transverse vertical sections, the radiating fibres of the optic thalami and corpora striata divide immediately into three very distinct superimposed planes.

The *first* or *superior plane* is reflected upwards and then inwards, so as to describe a curve with its convexity turned outwards, passes horizontally inwards to form the corpus callosum, and unites with the corresponding fibres of the opposite side.

The *second* or *middle plane*, the plane of the hemisphere, ascends parallel to the corpus callosum up to the point where the fibres of that body are reflected inwards; it then continues in an almost vertical direction, and thus reaches the grey matter.

The *third* or *inferior plane*, much smaller than either of the preceding, is extremely thin and follows a very different course: immediately after emerging from the common place of origin, it descends on the outer side of the corpus striatum, turns round its lower part, approaches the median line, and then mounts upwards, in contact with the corresponding plane of the opposite side, through the middle of the ventricles, where the two juxtaposed planes form the septum lucidum.

13. Is the fornix an antero-posterior commissure? In support of this opinion I may state, that I have seen the right half of the fornix atrophied in a case of destruction of the convolutions corresponding to the tentorium cerebelli.

14. The anterior commissure (*m, fig.* 283.), which was regarded by Willis as the commissure of the corpora striata, and by Reil as intended to connect the anterior convolutions of the middle lobe and some convolutions situated at the bottom of the fissure of Sylvius, belongs to the system of converging fibres, according to Gall, who describes them as commencing in the grey matter of the convolutions. According to Tiedemann, this commissure is a continuation of the cerebral peduncles, each of which, after having traversed the corpora striata, expands in the corresponding hemispheres, and gives off several radiating fasciculi which incline forwards and inwards, are collected together into a cord, and unite with those of the opposite side; the anterior commissure therefore, according to this view, is a bond of union between the radiating fibres of the cerebral peduncles and those of the right and left middle lobes of the brain. Chaussier had already derived the fibres of this commissure from the cerebral peduncles. All that is certainly known regarding it is, that the cord of which it consists passes through the anterior portion of each corpus striatum and expands in the anterior and inferior convolutions of the sphenoidal horn of the posterior [middle] lobes behind the fissure of Sylvius.

15. The cornu ammonis is formed by the reflection of the lower part of the hemisphere: the white laminæ which cover it, the corpus fimbriatum along its border, and the fornix, constitute but one system which evidently belongs to the antero-posterior commissures.

16. Each convolution is composed of two precisely similar semi-convolutions; the two halves, which can be readily separated by a stream of water, may be decomposed into a considerable number of striated lamellæ, arranged like a fan, the margin of which would correspond to the free border of the convolution and the narrow end to the adherent border; these striated lamellæ are separated from each other by vascular filaments; their number seems to vary in different subjects; they seem, moreover, to be altogether independent of each other. The stream of water detaches a corresponding layer of grey matter with each white lamella. This layer of grey matter is also striated and appears to be composed of fibres implanted upon the white matter, as Mr. Herbert Mayo has very clearly pointed out.

17. It follows, therefore, that in the convolutions, a lamellar striated arrangement succeeds to the fibrous or linear arrangement of the medullary centres and radiating fibres of each hemisphere.*

These lamellæ are evidently continuous with the radiating fibres of the corpus striatum and optic thalamus. Still there is in each convolution a proper lamella, the continuity of which with the radiating system of the hemispheres, I have not been able to trace.

18. We should not regard the convolutions as so many sinuous eminences separated by the anfractuosities: on the contrary, the bottom of the anfractuosity forms the middle part or fold of a layer of white and grey matter, half of which layer belongs to one convolution and half to the next convolution (*n n*, *fig.* 284.). Now it is these white lamellæ, which line the grey matter, that appear to be proper to each convolution; and between these proper lamellæ are situated the white striated plates that are continuous with the radiating fibres of the hemispheres †, which fibres are not arranged in lamellæ but merely in lines.

It follows from all that has been stated, that there are yet several deficiences in our knowledge of the anatomy of the brain, which prevent us from forming a complete idea of its structure.

Developement of the Cerebrum. ‡

In the early periods of fœtal life, about the end of the second month, the hemispheres are represented by a very thin membrane, which is turned backwards and inwards so as to cover the corpora striata.

The optic thalami, which appear as enlargements of the cerebral peduncles, the tubercula quadrigemina, and the cerebellum, are completely exposed. The corpus callosum does not yet exist. The human brain may then be considered as resembling the brain of fishes.

Towards the end of the third month, the membrane of the hemispheres has acquired a further developement, and covers not only the corpora striata but

* M. Leuret has been led to the same conclusion regarding the lamellar structure of the convolutions, by studying the brain hardened by boiling it in a solution of salt.

† Mr. Herbert Mayo (A series of engravings intended to illustrate the structure of the brain and spinal cord in man, 1825), who has followed the example of Reil, in examining the brain with so much care after it has been hardened in alcohol, admits the existence of three sorts of fibres in each convolution, viz. fibres which pass from one convolution to the next (*u u*, *fig.* 283.), and also to more distant convolutions; fibres which come from the commissures (*s s p*); and fibres derived from the spinal cord. According to this anatomist, the fibres which pass from one convolution to another constitute the principal part of each convolution; the other white fibres which form the centre of each convolution are derived partly from the commissures and partly from the optic thalami and corpora striata.

According to him, the white fibres (*y′ q*) which form the inferior layer of the cerebral peduncles radiate in the substance of the cerebrum, and constitute its anterior and middle fibres. The fibres proceeding from the optic thalami form the posterior cerebral fibres (*y*). There is, he affirms, one point in which *the radiating fibres evidently decussate* with the fibres from the great commissure of the brain or corpus callosum (as at *g*, *fig.* 284.). The posterior radiating fibres do not present this decussation.

The two most remarkable fasciculi of communication between the convolutions are the following: — that which occupies the bottom of the fissure of Sylvius (*l*, *fig.* 283.; *m*, *fig.* 284.), and which unites the convolutions of the anterior and posterior lobes; and that (*p p*, *fig.* 283.; *l*, *fig.* 284.) which runs above the corpus callosum, crossing at right angles the direction of its fibres, and connects the anterior and superior with the posterior and inferior convolutions.

Rolando has not been so successful in his researches into the structure of the cerebrum as in his investigations into that of the cerebellum: the following are the results which he obtained by tearing the brain, and by examining this organ in the fœtus. According to him, the brain is composed of fibres arranged in layers in the following order, proceeding from without inwards: — 1. a white layer reaching into the fissure of Sylvius, and covered by grey matter; 2. a layer from which the fibres of the external convolutions arise; 3. a layer which is formed by the fibres of the peduncles, and supplies the convolutions of the inner border of the hemisphere; 4. a plane which extends from the optic thalami to the parietes of the lateral ventricles to form the corpus callosum; 5. a system of longitudinal fibres which form the convolutions situated upon the inner surface of the hemispheres; 6. a system of medullary fibres which constitute the fornix and cornu ammonis; 7. internal and external corpora striata, to which must be added the anterior commissures, the perforated layer, and the fasciculus of the external corpus geniculatum.

‡ *Vide* Tiedemann (translated by M. Jourdan).

also the optic thalami. The tubercula quadrigemina and the cerebellum are still exposed. The anterior lobes only of the cerebrum are formed. The posterior lobes seem to be merely appendages. The hemispheres then constitute at this period a membranous sac which is open on the inner side and behind, and may be regarded as representing the brain of reptiles. The corpus callosum begins to appear under the form of a narrow commissure, which unites the two hemispheres in front, they being completely separated behind.

In the fourth and fifth months, the cerebrum covers the anterior part of the tubercula quadrigemina. The posterior lobe exists, the fissure of Sylvius, which is well-marked, separating it from the anterior lobe. We observe here and there some small depressions, the traces of anfractuosities. The olfactory nerves, which are very large, and are said to have been found hollow as in the lower animals, appear to arise from the Sylvian fissure. The corpus callosum is still very small, so that the optic thalami and the third ventricle are exposed. At this period, the human brain has some analogy with that of the rodentia.

In the sixth month, the cerebrum covers the tubercula quadrigemina and the greater part of the cerebellum. The only traces of convolutions are found upon the internal surface of the hemispheres. The corpus callosum is prolonged backwards with the hemispheres, and from being vertical now becomes horizontal.

At the seventh month, the corpora albicantia, which had hitherto formed a single mass, as in the lower animals, become separated. The convolutions are defined, and the cerebrum projects behind the cerebellum.

The changes occurring in the eighth and ninth months appear to be the developement of the convolutions and the perfection of the other parts of the brain. At this period, the characters of the human brain are well defined. It may not be impossible perhaps to recognise in the rapid phases of this developement, the characters of the brain in the different orders of mammalia; but it is necessary to observe greater caution in admitting these analogies than has been evinced by various naturalists.

As the corpus callosum continues to be developed backwards it ends by reaching the anterior tubercula quadrigemina.

The corpora striata do not exhibit their white, radiating fibres until near birth or soon after it. The originating fasciculi of the fornix are not seen in the interior of the optic thalami until the latter months of intra-uterine life; and until then also the transverse commissures and the white fibres of the optic commissure do not appear.*

The lateral ventricles are formed by the turning backwards and inwards of the membrane which constitutes the hemispheres. And as this membrane is very thin until the end of the third month, it follows that at this period the lateral ventricles are proportionally much larger than they are afterwards. The anterior cornua of these ventricles are developed before the descending cornua, and these before the posterior cornua. During all this period, the anterior cornua communicate with the cavities in the olfactory nerves. At the sixth month, the lateral ventricles are completely closed. The choroid plexuses, which exist in all animals provided with lateral ventricles, begin to appear as soon as these cavities.

The distinction between the grey and white matter does not become evident until after birth. Tiedemann is of opinion, that the formation of the grey matter takes place after that of the white. This appears to me a pure hypothesis. The two substances are formed at the same time; but, properly speaking, they are neither white nor grey, and they do not acquire their distinctive characters until some little time afterwards.

* [Tiedemann describes fibres as distinctly appearing in the corpus striatum in the sixth month, though not so abundantly as afterwards. He recognised the anterior and posterior commissures before the end of the third month; at the same time also, the anterior pillars of the fornix rising from the united mass of the corpora albicantia; the fasciculi from the thalami to the corpora albicantia were quite distinct in the fifth month, and could be recognised even somewhat earlier.]

Comparative Anatomy of the Cerebrum.

The Optic Thalami and Corpora Striata.

In analysing the brains of the lower animals, it is of the utmost importance clearly to distinguish the hemispheres, properly so called, from the optic thalami and corpora striata.

The *optic thalami* are recognised by their having a ventricle (the third) between them, by being connected by an anterior and a posterior commissure, and moreover by being continuous with the cerebral peduncles.

The size of the optic thalami is always proportioned to that of the hemispheres. In fishes, the cerebrum appears to be almost entirely formed by the optic thalami.

There are no traces of corpora striata in fishes. Their existence in reptiles cannot be doubted. They are of enormous size in birds, in which they constitute almost the entire hemispheres. If it be true that in the animal series the size of the hemispheres is always directly proportioned to that of the optic thalami, such is not the case with the corpora striata, which as I have already stated are a kind of internal convolutions, and are often inversely proportioned in size to the hemispheres properly so called.

Thus the corpora striata are very large in proportion to the hemispheres in the rodentia: in this respect, as in many others, the brain of this order of mammalia approaches very near to that of birds. In the higher orders of mammalia, as the carnivora and quadrumana, the proportion between the corpora striata and the hemispheres is nearly the same as in the human subject.

The Cerebral Hemispheres and Olfactory Lobes.

In Mammalia. Man surpasses all the mammalia in regard to the size of the *cerebral hemispheres* and the number of their convolutions.

The quadrumana stand next to man. The dolphin perhaps exceeds the ape in both respects, and this would tend to support the relations of travellers respecting the wonderful intelligence of this cetaceous animal.

In the carnivora and ruminantia, the hemispheres are smaller, the occipital lobe of the cerebrum does not exist, and the anterior part only of the cerebellum is covered. There is no fissure of Sylvius and no lobe of the corpus striatum. In all these animals, the number of the convolutions, and the depth of the anfractuosities, have appeared to me to be as great as they are in man, in proportion to the size of the hemispheres. I have not observed that regularity of the convolutions which several anatomists have pointed out as contrasting with their irregularity in man.

The lowest order of mammalia, namely the rodentia, have the least complicated brain. It is shaped like the heart on playing cards, almost resembling the brain of birds. The cerebellum is completely exposed, and the tubercula quadrigemina are but partially covered by the cerebrum. There are scarcely any traces of convolutions, and the hemispheres are reduced to a membrane folded upon itself.

The corpus callosum is extremely small, but the cornu ammonis is very large. These two parts seem to be developed inversely to each other. Thus the corpus callosum is larger and the cornu ammonis is smaller in man than in the lower animals.

In the rodentia, the grey matter of the convolutions is reflected beneath the fornix.*

In all mammalia, excepting the dolphin, the olfactory nerves, which are so delicate in man, form two thick pedicles lying under the anterior lobes of the cerebrum, and terminating in front by large ovoid bulbs, corresponding in size

* [Mr. Owen has discovered that the brain of marsupial animals resembles that of birds, in wanting the corpus callosum (see his Memoir in *Phil. Trans.* 1837).]

to that of the ethmoidal fossæ; these enlargements are named *olfactory lobes.* They are continuous with the innermost convolutions of the sphenoidal horn of the posterior lobe, which presents above and below certain white fibres or striæ that are continuous with the cerebral peduncles.

The olfactory lobes have no relation with the corpora striata, as Cuvier was the first to observe. In the dolphin as in man the corpora striata are very much developed.

The developement of the olfactory lobe is inversely proportioned to that of the cornu ammonis.

In Birds. The *cerebral hemispheres* in birds are shaped like a heart on playing cards as in the rodentia; there are no lobes and no convolutions, excepting a very superficial longitudinal furrow situated on each side of the median line. The brain almost entirely consists of the corpora striata. The hemisphere is formed by a very thin grey lamina, upon which are observed certain white radiated fibres. This lamina commences at the inner part of the corpus striatum, turns outwards round that body, and is continued to the upper part. The interval between this lamina and the corpus striatum forms the lateral ventricle. There is no trace of the corpus callosum, but there is evidently an anterior commissure, which expands in the corpora striata.

In all birds of prey, two medullary bands arise in front of the commissure of the optic nerves, and having reached the front of the hemispheres, are expanded to form the *olfactory lobes.* In the other tribes, as in the gallinaceæ, there are no olfactory lobes, but certain small cords, which are merely the tapered extremities of the hemispheres.

In Reptiles. The hemispheres are larger in the *chelonians* (tortoise) than in birds, though they are very similar in many respects: as in birds, there are no olfactory lobes, but merely two bands. In the saurians (crocodile, lizard), the olfactory lobe is continued into the tapering point of the cerebral lobe by a very long pedicle. The *batrachians* and *ophidians* have olfactory lobes in front of the hemispheres, from which they are separated by a circular constriction.

In Fishes. Like reptiles, fishes have sometimes a single pair, sometimes two pairs of lobes in front of the optic lobes. When there is only one pair, it must not be concluded that they represent the cerebral hemispheres; if that pair is continuous with the olfactory nerves, they constitute the olfactory lobes. Whenever there is a pair of lobes between the olfactory and the optic lobes, such pair belongs to the hemispheres.

The olfactory lobes and the cerebral hemispheres are so independent of each other, that they are often inversely proportioned in regard to size, so that the cerebral hemispheres are larger in man than in any of the lower animals, whilst the olfactory lobes are smaller. On the other hand, the olfactory lobes are the most highly developed in the ray: they are united together, are hollowed in the centre, grooved on the surface, according to the observation of Vicq d'Azyr, and present some traces of convolutions. Now, in the ray, there are no cerebral hemispheres, at least unless we agree with Tiedemann in regarding the olfactory lobes as analogous to the corpora striata. In some fishes the olfactory lobe is supported by a pedicle of variable lengths. As to the cerebral hemisphere, it is a mere tubercle, which appears to represent the optic thalamus.

The corpus callosum, the fornix, and the septum lucidum, do not exist either in birds, reptiles, or fishes.

The corpora albicantia, which are wanting in birds and reptiles, are of enormous size in fishes, and constitute a true lobe according to Vicq d'Azyr and Arsaky.

The encephalon of fishes presents five pair of lobes, which are, proceeding from behind forwards, 1. the lobes of the pneumogastric nerve, or lobe of the medulla oblongata; 2. the cerebellum; 3. the optic lobes; 4. the cerebral hemispheres; 5. the olfactory lobes.

If we now generalise, with M. de Blainville, the notions we have formed re-

specting the encephalon of vertebrate animals, we may regard the different pairs of lobes of the encephalon as so many pairs of ganglia situated upon the prolongation of the spinal cord; these he names *ganglions sans appareil extérieur.* The first or the most anterior pair consists of the olfactory lobes which are rudimentary in man. The second is the cerebrum properly so called. The third is formed by the tubercula quadrigemina or optic lobes which are rudimentary in man. The fourth is the cerebellum. The ganglia which constitute each pair communicate with each other; each ganglion communicates with that which precedes and that which follows it; and lastly, they all communicate with the spinal cord.*

* [There is still considerable uncertainty as to the parts of the encephalon which correspond in the higher and lower vertebrata. For further information on this point, as well as on the comparative anatomy of the brain generally, see Leuret, *Anatomie Comparée du Système Nerveux.* Paris, 1839.]

THE NERVES, OR THE PERIPHERAL PORTION OF THE NERVOUS SYSTEM.

General remarks. — History and classification. — Origin, or central extremity. — Different kinds. — Course, plexuses, and anastomoses. — Direction, relations, and mode of division. — Termination. — Nervous ganglia, and the great sympathetic system. — Connexions of the ganglia with each other, and with the spinal nerves. — Structure of nerves. — Structure of ganglia. — Preparation of nerves.

General Remarks.

The *nerves* which are concerned in the transmission of sensations and of motor influence are white cords attached to the cerebro-spinal axis by one extremity (the central extremity), and distributed to the different organs by the other or peripheral extremity. They have a pearly-white aspect, like the tendons with which they were for some time confounded. Their surface is smooth, and presents a number of folds or zigzag marks, which are effaced by extension.* Lastly, if a nerve be cut across, it is seen to be composed of a certain number of cords, the divided ends of which project beyond the cut surface. By these characters, it will always be easy to distinguish a nerve from any other white tissue in the body.

All the nerves are arranged in pairs; they differ from each other in their point of junction with the central portion of the nervous system; in their consistence; in the place at which they emerge from the cranio-vertebral cavity; in their distribution; and in their functions. These points of difference have served as the foundations of the different classifications of the nerves proposed at various periods.

History and Classification of the Nerves.

The nerves, which had been at first confounded with the tendons and ligaments under the name of white tissues, were distinguished from those parts by Herophilus and Galen. The subdivision of the nerves into the *cerebral* or *cranial* nerves which pass out of the foramina in the base of the skull, and the *spinal* or *rachidian* nerves which emerge from the intervertebral foramina, was so natural, that it suggested itself to the earliest anatomists who directed their attention to this system. The cranial nerves alone have presented some difficulties in their study and their classification. Marinus, whose work has been long regarded as classical, admitted only seven pairs of cranial nerves, among which neither the olfactory nor the pathetic were included. Achillini was the first who described the latter as a special nerve; and it was Massa who classed the olfactory ribbon among the nerves. Willis divided the cranial nerves (and his division is still adopted) into ten pairs, including the sub-occipital nerve. He also, like his predecessors, admitted thirty pairs of spinal nerves, and regarded the great sympathetic as forming the forty-first pair. According to Willis, the olfactory nerves form the first cranial pair; the optic nerves the second; the common motor nerves of the eyes, the third; the pathetic nerves, the fourth; the trigeminal nerves, the fifth; the external motor nerves, the sixth; the facial and auditory nerves together, the seventh; the pneumogastric, glosso-pharyngeal, and spinal accessory, the eighth; the hypoglossal nerves, the ninth; and the sub-occipital nerves, the tenth. This last pair, which was with so much reason classed by Haller among the spinal nerves, has been alternately and arbitrarily removed from one to the

* [These zigzag folds led some anatomists to believe that the nerves have a sinuous arrangement. Monro has even commemorated this anatomical error by a figure: the sinuous appearance common to the nerves and tendons disappears in both by stretching.

other class of nerves. Soemmerring divided the seventh pair of Willis into two distinct pairs, — the seventh, or the facial nerves; and the eighth, or the auditory nerves: he subdivided the eighth pair of Willis into three pairs, namely, the ninth, or the glosso-pharyngeal; the tenth, or the pneumogastric; and the eleventh, or the spinal accessory nerves of Willis. But Soemmerring's modification, as well as Malacarne's, who admitted fifteen pairs of cranial nerves, and also Paletta's, who described as a particular nerve that branch of the fifth pair which is distributed to the temporal and buccinator muscles, appear to me to be faulty, because they cause a confusion of ideas without leading to any advantage. We shall, therefore, adhere to the classification of Willis, which is most generally adopted. Nevertheless, with Vicq d'Azyr, we shall prefer a nomenclature founded upon the distribution of the nerves to one which is purely numerical.

Willis conceived the grand idea of separating the nerves of voluntary from those of involuntary motion. Bichat seized upon this idea, which had already been rendered fruitful by Winslow and Reil; he unfolded it even to the minutest details, and appropriated to himself in some measure the distinction of the nerves into those of organic and those of animal life. The cerebro-spinal nerves constitute the nervous system of animal life; the great sympathetic nerve forms by itself the nervous system of organic life. This last-named nerve consists of a series of ganglia, or small nervous centres distinct from each other and from the brain. Bichat, moreover, anticipating all the importance of the origin of the nerves, endeavoured to class them, not according to the points at which they emerged from the cranium, but according to their origin, viz. into the nerves of the cerebrum, which are ten in number; the nerves of the pons Varolii, six in number; and the nerves of the spinal marrow, thirty-four in number; the only disadvantage of this classification consists in its having been premature.

Other less important, and in general rather physiological than anatomical subdivisions of the nerves have been established. Thus, in reference to their consistence, the nerves have been divided into the *hard* which are motor nerves, and the *soft* which are sensory; the former are said to come from the spinal cord, the latter from the brain. The old distinction of the nerves into *nerves of sensation*, and *nerves of motion*, has been lately revived; and we shall have occasion to recur to it, as well as to Sir Charles Bell's classification of the nerves into the *symmetrical* or *primitive*, and the *superadded* or *respiratory* system.

The nerves might also be classified according to their size, but this mode of distinction would be completely useless. Every nerve presents for our consideration a central extremity, a course, and a peripheral extremity.

The Central Extremity of the Nerves.

The central extremity of the nerves is that part by which they communicate or are connected with the cerebro-spinal axis. It is generally called the *origin* of the nerves. The use of such metaphorical expressions as origin, production, and efflorescence, has not been without disadvantage to science; for by the majority of anatomists they are employed not in a figurative but in a literal sense.*

The examination of the central extremity of the nerves is perhaps the most important part of their study, because the properties of the nerves depend in a great measure upon their point of connexion with the central part of the nervous system. This point is, in reference to each nerve, constant and invariable, not only in man, but throughout the animal kingdom, so that its exact determination enables us to establish what are the analogous parts of the encephalon in different species.

* Comparative anatomy, and the anatomy of the fœtus, prove the independent formation of the different parts of the nervous system.

Each nerve has an *apparent* and a *real* central extremity or origin. The apparent origin is the exact point at which the nerve is given off from the surface of the cerebro-spinal axis; but as several nerves can be traced into the substance of the cerebro-spinal axis to a variable depth, it is probable that all of them have a much deeper *real origin*. The older anatomists proceeded on this supposition, when they described all the nerves as originating from the cerebrum, and more particularly from the corpus callosum, or rather from the optic thalami and corpora striata. We are still ignorant of any central point or *sensorium commune*, forming the point of termination or of origin to all the nerves of the body.

In respect of their origin, we might regard all the nerves as proceeding from the spinal cord: the nerves of the face, and those of the organs of respiration and deglutition, arise from the medulla oblongata and its cranial prolongations; the nerves of the upper extremity proceed from the cervico-dorsal enlargement of the cord; and the nerves of the lower extremity from the lumbar enlargement; the nerves of the trunk arise from the spinal cord between its three enlargements. The optic and olfactory nerves alone appear to form exceptions to this rule.

All the spinal nerves present the greatest uniformity in reference to their origin, course, and termination. The arrangement of the cranial nerves, which appears at first sight to be uninfluenced by the laws which regulate the distribution of the spinal nerves, may yet be referred to those laws to a certain extent, notwithstanding its apparent irregularity and complexity.

The general remarks which follow apply more particularly to the spinal nerves.

The spinal nerves arise by two sets of roots, the *anterior* (*a fig.* 267.) and the *posterior* (*b*).

Gall advanced the notion, that the posterior roots of the spinal nerves preside over extension, and the anterior roots over flexion of the trunk and limbs, and he explained the predominance of extension over flexion by the greater size of the former roots.* Although the fact of this predominance appears to me indisputable, Gall's explanation is nevertheless rendered void, for it supposes a separation of the fibres of the anterior and posterior roots in reference to their distribution, and no such a separation exists.

Sir Charles Bell, having proved by experiments that the facial nerve and the fifth cerebral nerve had different properties, the former being devoted to motion and the latter to sensation, was led to examine whether there did not exist something analogous in the other parts of the body; and the double roots of the spinal nerves must have naturally suggested themselves to his mind. Might not the object of this double origin be to concentrate a double property in each pair of nerves? Experiments were instituted, and they confirmed the preconceived ideas of this ingenious physiologist. They were soon followed by the perfectly confirmatory experiments made by Magendie, who, by also adducing facts in pathological anatomy, threw so much light upon this subject, that most modern physiologists have admitted that the *posterior roots belong to sensation* and the *anterior to motion.*

Now, notwithstanding the imposing authorities which I have quoted, I must say that I am by no means convinced of the reality of this distinction, and that, in repeating both Bell's and Magendie's experiments, the section of the anterior and that of the posterior roots appeared to me to produce precisely the same effects.†

I have also endeavoured to determine the question anatomically.

* In this matter Gall has caught sight of a truth which I believe I have established upon incontestable evidence, in describing the apparatus of locomotion; namely, that in all parts of the body, excepting in the muscles of the fingers, the extensors are more powerful than the flexors.

† [The accuracy of these experiments has now been amply confirmed; and there is no doubt that the anterior are the motor and the posterior the sensory roots: no difference of structure has been detected between them.]

Some anatomists have thought that, after emerging from the ganglion, the filaments from the two roots become so intimately mingled that the smallest nervous cord would contain filaments from both the anterior and the posterior root; as far as I have been able to ascertain, the filaments are interlaced but never enter into a regular combination. Again, in order to render the dissection more easy and conclusive, having macerated a portion of a body in water containing nitric acid, and having thus destroyed the neurilemma or fibrous covering of the nerves, I endeavoured to trace some nervous filaments, both cutaneous and muscular, to their origin; but I never could succeed in this, so numerous are the combinations into which the filaments enter. However, having directed my attention more particularly to certain filaments given off from the cervical nerves to be distributed to the scaleni muscles, I succeeded in tracing them into the corresponding spinal ganglia. Now, the filaments which proceed directly from the spinal ganglia are, according to the theory just alluded to, exclusively connected with sensation, and consequently should not be distributed to the muscles.

The question of the anterior and posterior roots is connected with another more general question, viz. are there different kinds of nerves?

Different Kinds of Nerves.

The natural distinction of the nerves into those of sensation and of motion dates as far back as Erasistratus, who described the sensory nerves as arising from the meninges, and the motor from the cerebrum and cerebellum. This opinion was often revived and always abandoned, and it was only when direct experiment appeared to confirm the anticipations of theory that it became generally adopted.

Bichat, after the example of Winslow and Reil, divided the nervous system into two great sections, one of which belongs to animal and the other to organic life. The spinal cord and encephalon form the common centre of the *nervous system of animal life*; the organs of the senses and the muscles are under its influence. All the organs supplied by it are subject to volition and consciousness. The *nervous system of organic life* is formed by the ganglia of the great sympathetic, which Bichat agrees with Winslow in regarding as so many little brains. The organs of digestion, respiration, circulation, and secretion are under its influence. All of the organs which it supplies are withdrawn from the control of the will and of consciousness.

The sub-division adopted by Reil and Bichat prevailed in the science, until Sir Charles Bell was led back to the opinion of the ancients by some highly interesting observations and experiments; he associated with that opinion the ideas of Bichat, and also established an entirely new class of nerves, which he named *nerves of expression* or *respiratory nerves*. According to this view there are five kinds of nerves: *nerves intended for special sensations*, as the nerves of smell, of vision, and of hearing; *nerves of common sensation*; *nerves of voluntary motion*; *nerves of the respiratory movements*; and *sympathetic nerves*, which appear to unite the body into a whole in relation to its nutrition, its growth, and its decay. By a still wider generalisation, Sir Charles Bell admits two systems of nerves; viz. *the primitive* or *symmetrical nerves*, which exist in all animals, and by the aid of which they feel and move. And secondly, the *superadded*, *irregular*, or *respiratory nerves*, the number of which is proportioned to the perfection of the general organisation. It is the latter system of nerves that regulates the partly voluntary and partly involuntary act of respiration, and also the several movements connected with it, such as those of speaking, laughing, sighing, and sneezing. According to Bell, these nerves arise from a special tract in the cord, and sometimes proceed separately or distinct from the other nerves, and are sometimes blended with them, this occurring in such a manner that neither their union nor their separation in any way impedes their functions.

This theory of superadded or respiratory nerves is very ingenious, but altogether hypothetical. Besides, it is only strictly applicable in the case of four nerves, viz. the pneumogastric, the glosso-pharyngeal, the spinal accessory, and the facial. Sir C. Bell's opinion concerning the existence of a column situated between the anterior and posterior roots of the nerves, along the whole extent of the spinal cord, and giving origin to certain filaments which combine with those coming from the two roots so as to cause them to participate in the great phenomena of respiration, is quite gratuitous.

On endeavouring to decide whether there are several kinds of nerves by anatomical investigation, it is found that, excepting the olfactory, optic, and acoustic nerves, which have altogether a peculiar arrangement, and the ganglionic nerves, which are generally greyer and more slender, there is no difference in the character and structure of the nerves of different parts of the body. The cutaneous nervous filaments are exactly similar to the muscular nervous filaments.

From the law of organisation, that identity of structure is always connected with identity of function, I have been led to admit that the nerves are *homogeneous;* that the different properties attributed to them belong to the organs to which they are distributed; and that they perform no other office in the economy than that of *conductors,—conductors of sensation* when they are distributed to a *sensory* organ, and *conductors of motor influence* when they enter a *motor* organ.* This view of the homogeneous structure of the nerves explains much more readily than the opposite one, all the phenomena of innervation, and in particular the unity of all parts of the nervous system.

Moreover, if we admit the existence of special nerves to preside over some special phenomena, and to be distributed to particular organs, why not admit them for all special actions and for all organs? There would then have to be digestive nerves, generative nerves, and secreting nerves of different kinds.

Course, Plexuses, and Anastomoses of the Nerves.

The course of the nerves must be examined both whilst they are within and whilst they are outside the cranio-vertebral cavity. Within this cavity the extent of their course is variable; and their distribution, after they have emerged from it, is more or less complicated. All, or nearly all, the cerebro-spinal nerves communicate with the great sympathetic system. When the parts to which they are destined are not complicated, their distribution is very simple, as, for example, the nerves of the thoracic and abdominal parietes; but when those parts are complicated, the arrangement of the nerves is proportionally intricate; and they then unite so as to form certain interlacements called *plexuses*, as, for example, the thoracic and abdominal plexuses.

The nervous *plexuses*, which Bichat regarded as so many centres in which the branches of origin of the nerves ended, and from which their terminal branches commenced, are formed by the division and subdivision of a certain number of nerves, which enter into new combinations, and form an almost inextricable interlacement.

Within these plexuses there is generally so intimate a combination of the different elements of which they are composed, that it is almost impossible to determine exactly what branches of origin are concerned in the formation of any particular terminal branch. A branch of a nerve issuing from a plexus belongs therefore to all the nerves which enter into the composition of that plexus.

The plexuses do not consist of actual anastomoses of the nervous cords; nor do they, as Monro believed, contain any grey matter: they do not afford

* The homogeneous structure of the different nerves is proved by the anatomical fact, that the same nerve is distributed to a great number of organs having very different functions, as, for example, the eighth pair; and also by a fact in comparative anatomy, namely, that the same pair of nerves may, in different species, preside over totally different functions — for example, the fifth pair.

origin to any new nervous filaments, but they merely give off those which they have received. The most careful examination reveals nothing more than an interchange of nervous cords, which, although they enter into new combinations, still remain independent of each other.

The term *nervous anastomoses* is applied to the communications by loops, or at more or less acute angles, which take place between the nervous filaments. The older anatomists, governed by the idea that there existed a fluid circulating in the nerves, supposed that in the anastomoses of nerves there was a mixture of nervous fluids, nearly similar to that which takes place in vascular anastomoses, where two different columns of blood are intermixed. They regarded the nervous anastomoses as the most active source of sympathies. Bichat also admits the existence of these anastomoses, in which, he says, there is not only a contiguity but also a continuity of nervous filaments. Beclard * defends the use of the term anastomosis, and endeavours to define its meaning thus,— " there is not merely an application of nervous filaments in the anastomoses, but a true communication, a junction (*abouchement*) of their canals which in truth contain a fixed substance, not a circulating fluid, as was formerly believed."

But on examining the structure of the nervous anastomoses, it is seen that there is simply a juxtaposition of filaments derived from two different sources. The examination also proves most distinctly that the anastomoses are merely small plexuses, so that the only difference between them is, that, *in the plexuses, there is an interchange of nervous cords, whilst in the anastomoses there is an interchange of nervous filaments or of primitive fibres.* The anastomoses, like the plexuses, are intended to concentrate the action of several nerves upon any given point, as on a centre, from which their action may extend to certain parts necessarily connected in function.

The nervous loops described by Bichat upon all points of the median line of the body, and by the existence of which he supposed that he could explain the return of sensation and voluntary motion to paralytic parts of the body, do not exist. The only anastomoses in the middle line with which I am acquainted are those of the two pneumogastric nerves, behind the lower extremity of the trachea, that of the two solar plexuses, and that of the cardiac nerves.

The Direction, Relations, and Mode of Division of the Nerves.

The nerves are very deeply situated at their egress from the cranio-vertebral cavity. Thus the brachial plexus is protected by the osseous girdle of the shoulders, and the sacral plexus by the pelvic bones. The nerves then pass into the great cellular intervals, which we have already described as existing in the limbs for the reception of the principal vessels and nerves, and for the preservation of those parts from pressure.

The direction of the nerves is generally *straight*, and their length corresponds exactly with the distance from their point of origin to that of their termination, so that, if the movements of the limbs exceed their ordinary extent, the nerves may suffer severe injury by being stretched. This *straight direction* is, in general, an essential character of a nerve. Nevertheless, a considerable number of nerves deviate from their primitive direction †, so as to describe a portion of a circle, or are seen reflected upon themselves in a direction precisely opposite to their original one. Others describe a zigzag course like the arteries, but these flexuosities are effaced in certain positions of the body, or during the distension of particular organs.

Although there is but one arterial trunk for each limb, there are always

* Anat. Generale, p. 659.

† I do not think that a straight direction is necessary for the transmission of the nervous influence, for this takes place in a flexed limb along a curved nerve, as well as in an extended limb along a straight nerve; but it is probable that it shortens the duration of this transmission.

several nerves, the number of these being variable. As the arteries often deviate from their original direction, they describe certain turns, so as to occupy alternately the opposite sides of a limb. Now, as the nerves pass in a straight direction, and the arteries describe certain curves, it follows that the same nerves cannot accompany the same arteries during the whole of their course. Thus when an artery deviates from its primitive direction, it has two satellite nerves, one during the first, and the other during the second part of its course. For instance, the crural nerve accompanies the femoral artery, and the sciatic nerve the popliteal artery. When an artery bifurcates or otherwise divides, there is often a particular nerve for each subdivision; thus the median nerve is the satellite of the brachial artery, the radial nerve accompanies the radial artery, and the ulnar nerve the ulnar artery.

It follows also from what has been said, that the nerves have no accompanying vessel for a more or less considerable portion of their course; such is the case with the great sciatic and the pneumogastric nerves.

The relations of the arteries with the nerves are constant, so that modern surgeons attach great importance to these relations; in fact, as a nerve on account of its whiteness is more easily recognised than an artery, as soon as the former is exposed the latter is immediately met with. It is important moreover to determine with the greatest accuracy what nerves are contained within, and what nerves are situated without, the sheath of their corresponding artery. Besides its principal nervous trunk, an artery is also accompanied by certain nervous filaments, which are closely applied to the vessels, which are very difficult to separate from it, and which often escape observation from their tenuity. These are the filaments which render ligature of the arteries so painful.

Division of the nerves. During their course, the nerves do not divide like the vessels by ramifying into smaller and smaller branches: but they give off in succession as they proceed branches to the different parts through which they are passing, and thus become gradually exhausted, until reduced to mere filaments themselves they terminate in the same manner as their branches. *The subdivision of nerves, therefore, does not consist in a ramification but in a process of separation or emission.* There is one circumstance which has attracted the attention of all anatomists, viz. that the nerves do not diminish in size, in proportion to the number of filaments given off from them: some of them even appear to increase in size after having given off several filaments. This apparent singularity is explained, not by the fact that new filaments are added, but by the flattening of the nerve, the separation of its filaments, the addition of a certain quantity of adipose tissue, or the thickening of the neurilemma.

Termination of Nerves.

The distribution of the nerves is perfectly determinate; each nerve indeed has its own distinctly limited department; an arrangement which, connected with what has already been said regarding the anastomoses, explains why the nerves cannot supply the place of each other. When the principal arterial trunk of a limb is tied, the circulation is re-established by the collateral vessels; but when a nerve is cut across, all the parts to which it is distributed are paralysed.

The termination of the nerves is undoubtedly one of the most important points in their anatomy. In the skin, the nerves terminate in the papillæ, not one of which is destitute of them; in the muscles, they terminate in extremely delicate filaments, which pursue a very long course in the substance of these organs, before they become invisible to the naked eye or to the eye aided by a lens: it has appeared to me that each nervous filament was so arranged as to be in contact with a very great number of muscular fibres, situated either in the same or in different planes.

It is probable that there is not a single muscular fibre which is not thus lightly touched by a nervous filament: this anatomical fact may suggest, instead of Reil's ingenious hypothesis of an atmosphere of activity around each nervous filament, the important *conclusion that the nerves act upon the muscular fibre by the effect of contact.**

MM. Prévost and Dumas believe that the nervous filaments terminate by loops in the substance of muscles; and upon their incomplete observations they have founded a theory of muscular contraction. Nervous loops may certainly be observed in the substance of the recti muscles which they selected as examples; but these loops are not the termination of the nerves, for a number of filaments are seen to issue from them and to be distributed in the manner just pointed out.†

The different organs vary much in regard to the number of nerves which they receive; the organs of the senses — the eyes, the ears, the nasal fossæ, the tongue, and the skin, stand first in this respect. Next to these rank the muscles which receive nerves in proportion to the number of their fibres and to their activity. The organs of nutritive life are far removed from the preceding in regard to the quantity of nerves distributed to them. No proper nerves have yet been discovered in cellular tissue, serous membranes, tendons, aponeuroses, and articular cartilages. All the articulations are provided with nerves, called *articular*, which may be traced into the ligaments, and even upon the synovial membranes.

The long bones in addition to their central or medullary nerve have certain periosteal nerves which are lost in the periosteum, and also proper nerves of the spongy tissue, which enter the foramina at the extremities of these bones.

The Nervous Ganglia and the Great Sympathetic System.

The *nervous ganglia* are certain greyish knots or swellings situated along the course of the nerves, and having a rather close resemblance to the lymphatic glands or ganglia. Considered generally, the ganglia are a kind of nervous centres towards which a certain number of filaments converge, and from which they again pass out under new combinations. Hence arose the ingenious idea of Winslow, who compared the ganglia to little brains; an idea which was revived under a modified form by Bichat, who made it the basis of his admirable chapter upon the nervous system of organic life.

The nervous system of invertebrate animals is reduced to a series of ganglia and ganglionic nerves: Swammerdam, Haller, and the older anatomists regarded this series of ganglia as a spinal cord enlarged at intervals. But there is no point of comparison between these two parts: in a word, the enlargements of the spinal cord and brain cannot be likened in any respect to the ganglionic enlargements.

There are three series, or, as some say, three kinds of ganglia: viz. the *spinal* or *rachidian ganglia*; the *intercostal ganglia*; and the *splanchnic ganglia*; these last are situated near the viscera for which they are intended.

The first series, or the spinal ganglia, belong to the organs of relation. They are constant, regular, and symmetrical, like the nerves upon which they

* This hypothesis of a nervous atmosphere was suggested to Reil, by the theory of a *nervous fluid*, which he regarded as analogous to and almost identical with the electric fluid; and also by the fact that the nervous apparatus is not able to supply filaments to all the muscular fibres.

† [The loops described by Prévost and Dumas seem to have consisted of small nervous cords; but Valentin, Emmert, and Burdach, have observed that the ultimate filaments (primitive fibres of Müller) have a loop-like termination in the muscles. In reference to the nerves of sensation, it has been observed by Valentin and Burdach, that in the frog's skin the primitive fibres end in loops; this mode of termination has also been seen by Schwann in the tail of the larva of the toad, and in the frog's mesentery. Schwann further states, that in both these cases the nervous fibres gave off exceedingly small fibrils, on which minute swellings (ganglia) were placed, and which in some situations formed a network. In the papillæ of the human skin, Breschet thought he saw the nerves ending in loops; and Gherber believes that he has seen these terminal loops in the skin of quadrupeds. Observers differ in their account of the mode of termination of the optic and auditory nerves (see ORGANS OF SIGHT AND HEARING).]

are placed. The other two series are destined for the apparatus of nutritive life, and constitute the *great sympathetic* system, improperly called the *ganglionic system*.

The identity in nature between the spinal ganglia and the ganglia of the great sympathetic, and also between the cerebro-spinal and the ganglionic system of nerves, is demonstrated by the fact that in a great number of animals the ganglia are blended, or as it were fused together. M. Weber (*Anat. Comparée du Nerf Sympathique*, 1817) has observed that in animals the developement of the great sympathetic is always inversely proportioned to that of the spinal cord. He has established a similar relation between the great sympathetic and the pneumogastric nerve; and indeed in certain species the latter nerve entirely replaces the former.

The experiments of M. Legallois upon the spinal cord led him to admit that the visceral nerves are under the influence of the spinal cord, and that the roots of the great sympathetic are in the cord.

There are as many spinal ganglia on each side as there are spinal nerves. The ganglia of the great sympathetic in the sacral, lumbar, and dorsal regions, are as numerous as the spinal ganglia; in the cervical region, there are only two or three sympathetic ganglia to correspond to the eight spinal ganglia. The superior cervical ganglion may be supposed to represent several ganglia.

In the cranium it is difficult to find any ganglia corresponding to the spinal; still the Gasserian ganglion, and the ganglion of the eighth pair, may be regarded as analogous to them.

On the other hand, we may regard the ophthalmic ganglion, the spheno-palatine or Meckel's ganglion, the otic ganglion, and even the upper part of the superior cervical ganglion, as forming the cranial ganglia of the sympathetic system.

Nevertheless, it would perhaps be more rational to regard the ophthalmic and otic ganglia as quite independent of the three above-mentioned series of ganglia, and as connected with certain local functions. There are a considerable number of these local ganglia, which have received no particular names, and which I shall hereafter point out.

Connexions of the Ganglia with each other, and with the Cerebro-spinal Nerves.

The spinal ganglia belong specially to the posterior roots of the spinal nerves; but it will presently be seen that the anterior roots are not altogether unconnected with them.

From the *spinal ganglia* proceed three branches, viz. a middle branch forming the continuation of the spinal nerve, an anterior or ganglionic branch proceeding to the corresponding ganglion of the great sympathetic, and a posterior branch which is distributed to the muscles and skin on the posterior region of the trunk.

Each of the *ganglia of the great sympathetic* receive one or several filaments from the spinal ganglia, and also a connecting cord from the sympathetic ganglion immediately above it; and each of them gives off a connecting cord to the ganglion next below it, and also certain visceral branches, which sometimes terminate directly in the viscera, and sometimes, when their distribution is complicated, proceed to the splanchnic ganglia.

Not unfrequently the communicating cords between some of the ganglia of the sympathetic are wanting, and the continuity of this nerve is then interrupted. Bichat relies chiefly upon this interruption in support of his opinion, that the great sympathetic is not a nerve properly so called, but that each of its ganglia is the centre of a small special nervous system, equally distinct from the cerebro-spinal system and from the other ganglia.

The *splanchnic ganglia* are the centres or points of convergence of a great

number of nerves, of which some are derived directly from the cerebro-spinal system, and others from the ganglia of the great sympathetic. In those splanchnic ganglia which approach the median line, the nerves of the right side become blended with those of the left by a great number of plexiform branches, which have a ganglionic aspect, surround the visceral arteries, and are subdivided with them to enter the substance of the viscera.

It follows then from what has been just stated, that the great sympathetic is neither a continuous nerve differing from other nerves only by having enlargements, as was believed by the older anatomists, who described the right and left sympathetic as constituting a special pair; nor is it, as Bichat conceived, a linear series of small nervous centres or little brains, which give off in all directions connecting filaments, both to the spinal and to the visceral nerves; it is a series of ganglia connected with one another in their action, and originating from each of the spinal nerves given off from the cerebro-spinal axis. It does not arise from the sixth cerebral nerve, nor from the vidian or carotid filaments, more than from any other spinal nerve; but it takes its origin from the whole spinal cord; and if it does not diminish in size as it recedes from the brain, but even increases at some points, this is because it receives new filaments of origin during its course.

According to an ingenious hypothesis, which is fully confirmed by anatomical facts, the viscera which receive their nerves from the ganglia of the great sympathetic derive their principle of action from the whole spinal cord, so that an affection of one nerve, or of one visceral ganglion, must affect the whole ganglionic system, in consequence of the intimate connexions between all the ganglia; and also the cerebro-spinal system, from the connexions between the sympathetic ganglia and the spinal cord. It would follow from this that the sympathetic and the splanchnic ganglia together constitute one vast plexus, which connects in an intimate manner the several viscera with each other and with the rest of the body. This mutual dependence and sympathy is the chief characteristic of the organs of nutritive life, that is to say, of the organs which receive their nervous filaments from the splanchnic and sympathetic ganglia.

Structure of the Nerves.

Prochaska was the first to throw any light upon the obvious structure of the nervous cords, and to prove that they consisted of true plexuses. Reil, not being contented with noticing the plexiform arrangement of the nervous cords, endeavoured especially to determine their structure; and he failed only because he selected the optic nerve as the type of the other nerves, whereas its structure happens to be exceptional.

Each nerve consists of a plexus enveloped in a common fibrous sheath. If this sheath be opened, and the small nervous cords contained within it are spread out by tearing the cellular tissue, it is found that these small cords, which at first seem to be parallel and in juxtaposition, anastomose in a great number of ways, so as to form an extremely complicated plexus. It is also seen, that the cords are of unequal size, not only in the same nerve, but also in different nerves; they are smallest in the branches of the great sympathetic and pneumogastric, and are largest in the nerves of the arm and in the great sciatic nerves.

On spreading out a nerve, with its component cords separated from each other, upon a plate of wax, and keeping those cords asunder by pins stuck at intervals, the absolute impossibility of following them through their successive subdivisions, and the multiplicity of their combinations, will become quite apparent.

The nerves consist essentially of two parts, viz. the *nervous matter properly so called*, and its *envelope* or *fibrous sheath*, which has been called the *neurilemma.*

There is a common neurilemma or common fibrous sheath for each nerve. Besides this, each small nervous cord and each fibre is provided with a proper

sheath or neurilemma. The neurilemmatic canals divide, subdivide, and anastomose like the small nervous cords themselves.

The neurilemmatic canals are composed of fibrous tissue: their shining aspect (which has caused them to be frequently mistaken for tendons), their strength, their inextensibility, their low degree of vitality, in fact all their characters, clearly prove their fibrous nature and exclusively protective function.*

The neurilemma of the nerves is continuous with the neurilemma of the spinal cord.

Nervous matter. If, as was shown by Reil, a nerve be immersed in diluted nitric acid, its neurilemma will be dissolved (rendered transparent), whilst its nervous matter will become remarkably dense and opaque. We shall hereafter see how valuable is this double property of acids in their action upon nerves for determining the true character of fibres supposed to be nervous. In a nerve thus prepared it is seen most clearly, that the nervous filaments of which it is composed are continually anastomosing by loops or at certain angles; and that the addition of one set of filaments to the trunk of the nerve, or the separation of others from it, necessarily interrupts the chain of their relations at the very point where it seemed possible to ascertain them, so that after every few inches the component parts of a nerve are completely changed.

What is the structure of the nervous matter? It is not a pulp, but is composed of pencils of exceedingly fine filaments, which may be compared to the fibres of raw silk: these filaments are parallel and in juxtaposition; they are free throughout the whole length of the nerve, and may be distinctly separated from each other; when not stretched, they are flexuous like a waved line. Each nervous filament reaches the entire length of the nerve. In each nerve, the filaments of which the fibres are composed pass continually from one fibre to another, and enter into an immense number of combinations, without ever becoming blended together.

This structure, which is so evident in a nerve hardened by nitric acid, is not less distinct in nerves which have undergone no preparation.† On puncturing the neurilemma, the nervous matter protrudes through the opening, precisely in the same way as the substance of the spinal cord protrudes under similar circumstances. On dividing the neurilemma along the whole length of the nerve, the nervous matter appears like long parallel filaments, of a milk white colour, which float in water if the nerve be immersed in that fluid.

Every nervous filament (and this is a fundamental point in their anatomy) has its central extremity in the cerebro-spinal axis, and its peripheral extremity at its point of termination. During the whole of its long course, it only enters into new combinations, without ever being interrupted.

Continuity is a law of the structure of the nervous filaments.‡

Can the nerves be injected?

The doctrine of a nervous fluid, which so long prevailed in the schools, led physiologists to admit the existence of canals for the circulation of this fluid. Several experimentalists stated that they had collected the nervous fluid, and

* It may be said that the neurilemma owes its fitness as a protecting organ as well to its low vitality as to its strength. This low degree of vitality of the neurilemma is the cause why nerves are constantly seen passing through inflamed or degenerated parts without being affected themselves.

† I have also examined this structure in living animals, whilst endeavouring to determine the insensibility of the neurilemma and the sensibility of the nervous filaments.

‡ [The nervous filaments (primitive fibres of Müller) are simple tubes, containing a thread of a soft semi-transparent substance; they are continuous with the white fibres of the brain and spinal cord at the apparent origin of the nerves. The primitive fibres of the nerves resemble those of the brain and cord in the nature of their contents, but they are larger, and their tubular, homogeneous sheath is much more distinct and is firmer, so that they do not become varicose. The olfactory, optic, and auditory nerves, however, are exceptions to this rule; their fibres resembling those of the brain and cord, in their size, delicacy, and liability to become varicose. No differences have been observed between the fibres of the other cranial and spinal nerves, nor yet between those of the motor and sensory roots. The sympathetic nerve, and all which receive fibres from it, contain, besides the ordinary nervous fibres, a greater or less number of jointed fibres (grey fibres, *Müller;* organic nervous fibres, *Schwann;* cellular tissue, *Valentin*) exactly like those found in the ganglia and in the grey matter of the brain and spinal cord.]

they even described its properties; and anatomists instituted no researches to confirm or refute these assertions. Malpighi himself, who, in reference to the study of anatomy, carried to such an extent that system of philosophical scepticism which has completely revolutionised all science, believed that he saw the nervous fluid escape from the cut end of a nerve, like a glutinous juice, which he compared to spirits of turpentine.*

Reil and some others have injected the neurilemma. Reil describes a very ingenious method of injecting the optic nerve, which consists in opening the transparent cornea, and injecting mercury into the globe of the eye: the mercury passes through the foramina, which transmit the filaments of the optic nerve at the point where these become continuous with the retina.

Such was the state of our knowledge when Bogros, prosector to the Faculty, having accidentally punctured a nerve with the tube of a mercurial injecting apparatus, observed that the mercury ran along the punctured nervous fibre, and also into the adjacent nervous fibres; he repeated and varied his experiments in a great number of ways, and soon published a memoir, in which he formally announced as a demonstrated fact, that in each nervous fibre there was a central canal capable of being injected; and in his enthusiasm at his discovery, he thought that he had realised the desire of Ruysch †, and that he could henceforth trace the nerves to their very finest terminations.

The work of Bogros was in general received with little favour; and, I think, has not been estimated at its real worth. Having renewed his experiments, I have arrived at the following result. If, with a pair of blunt pincers, a nervous fibre be raised from the centre of the nerve to which it belongs (from the middle of the median nerve for example), and if the tube of the lymphatic injecting apparatus be inserted accurately *into its centre*, the mercury will be seen to run by jerks, either downwards or upwards, along the centre of the nervous fibre, and to pass into a variable number of the adjacent fibres; if the injection be a successful one, the greater number of the fibres of the nerve will be injected throughout their whole length. Gentle pressure with the finger, or with the handle of the scalpel, greatly facilitates the progress of the mercury; but it often happens that the parietes of the canal through which the mercury is passing yield at some point, a rupture ensues, and the fluid is extravasated.

When the nervous fibre has not been punctured in the centre, the mercury is seen to run along the injected fibre, and even into some of those near it; but the mercurial column is never regular; it does not occupy the centre of the fibre, but only one side of it; and it is soon extravasated into the neurilemmatic sheath, which in a short time bursts.

This second kind of injection, which may be made at will by puncturing the fibre superficially, differs essentially from the former one obtained by introducing the pipe into the centre of the fibre. In the latter case the small column of mercury is uniform and regular, and its metallic lustre is as it were observed; the fluid runs rapidly; the nervous canal is less easily ruptured; and, when this does happen, it is preceded by a protrusion of the nervous matter; then the mercury is extravasated into the neurilemmatic sheath, and it pursues the same course as it would have taken if the nervous fibre had been punctured superficially in the first instance.

Where do the injections pass in these two cases? In the second method, that is to say, when the nerve is punctured superficially, it is the neurilemma that is injected. But in the method of central injection, is the nervous matter

* But, as Haller remarks, Malpighi only saw this upon cutting through the cauda equina, and never observed it in the section of any other nerves; now, it is extremely probable that he saw merely the serous fluid which is most commonly found in the lower infundibiliform portion of the spinal dura mater: "Quàm vehementer suspicor eum clarum virum humorem vidisse viscidum, quo infundibulum duræ membranæ spinalis frequentissimè plenum est, et qui idem in spinam bifidam auctus abit." (Haller, *Elem. Physiol.* t. iv. p. 197.)

† Ruysch said that he should have nothing to desire, if he could succeed in injecting the nerves as he had done the vessels.

itself injected? Bogros believed that it was, and he even asserted that he had seen a central canal with the naked eye; but no such canal exists; and the one which he showed after desiccation of an injected nerve was artificially made, as we shall immediately find. How, indeed, can we admit the existence of a canal in nervous matter, which we have shown to consist of a pencil of parallel and juxtaposed filaments?

If therefore, in the central injection, the mercury neither enters into the nervous matter, nor is contained in the neurilemma, where is it situated? Is it in lymphatic vessels? We do not know; for lymphatics have not been shown by any one. Are they arteries or nerves? To this it may be answered, that the bloodvessels do not follow the direction of the nerves.

All this is explained by the following fact: each nervous fibre, besides its common neurilemmatic sheath, has also a *proper sheath*, in contact with the neurilemma by its outer surface, and with the bundle of nervous filaments by its inner surface, which is smooth and moist. This sheath may be demonstrated by cutting a nerve across, and seizing one of the tufts which project beyond the retracted neurilemma; a nervous fibre can then generally without effort be drawn out several inches, having a smooth surface, and being completely freed from its common neurilemma. Now this fibre consists not only of nervous matter, but also of a *proper sheath* perfectly distinct from the neurilemma. It may now be injected, and will then present all the characters of the central injection already mentioned; and upon examining it with a lens it will be seen, that the nervous filaments of which it is composed are regularly distributed around the column of mercury.

It follows then that in the central injection of a nerve it is neither the neurilemma, nor the nervous matter, nor the vessels that are injected, but *the proper sheath of each nervous fibre;* and that the passage of the injection from one fibre to a great number of others depends on the canals formed by the proper sheaths anastomosing with each other.

I shall further remark, that in this injection the mercury evidently penetrates into a regular canal, and not into one produced by its own weight, for a column of a few lines is sufficient for the purpose.

Again, the mercury runs more easily from the peripheral towards the central extremity of a nerve than in the opposite direction, and when the injection is successful, the spinal ganglia are filled with the mercury, which is then either extravasated into the cavity of the dura mater, or escapes by the veins. If it be asked, why the mercury does not pass into the anterior and posterior roots of the nerves? I should answer, that it is not certain that the fibres of these roots have any proper sheaths; or if so, they are very readily lacerated. As to the passage of the mercury from the nervous ganglia into the veins, it is probable that the proper sheaths terminate in the ganglia, so that the mercury is extravasated into the tissue of which the ganglia consist.

Injections afford a good means of tracing the nervous filaments into the substance of organs. An injection thrown into the lingual branch of the fifth nerve penetrates as far as the papillæ of the tongue.

Structure of the Ganglia.

Meckel, in his excellent monograph upon the fifth pair, advanced the opinion that the nerves divided in the ganglia into a multitude of fibres which are intended for a great number of parts.

Zinn (Acad. Berlin, 1753) said, that the nerves not only divided within the ganglia into a great number of fibres, and were directed by them from the centre to the circumference, but that they were also mingled and combined in the ganglia in such a manner that a great number of fine fibres united into a smaller number of fibres of greater diameter.

But this doctrine, however specious it may be, not resting upon any anatomical fact, was rejected by Haller. Scarpa undertook a series of researches in order to render our knowledge more complete regarding this subject. Instead

of boiling the ganglia or macerating them in vinegar, urine, and other liquids, Scarpa was contented with macerating them in pure water frequently renewed—a method practised by Ruysch in his delicate investigations; by means of this simple proceeding he was able to demonstrate that the ganglia are formed by a number of nervous filaments surrounded by cellular tissue and by a grey matter which is destroyed by maceration.*

He carried his researches not only into the anatomy of the spinal, but also into that of the visceral ganglia, and he discovered a wonderful uniformity in the structure of the one and the other. He compared their structure to that of the plexuses; both of them receive nerves from all sides, which nerves are then intermixed without becoming united; and both generally give off a greater number of nerves than have assisted in their formation.

The injection of the nervous ganglia from the nerves has enabled me to discover that these ganglia have a precisely similar structure to that of the lymphatic glands; they are composed of cells communicating with each other, and among which the nervous fibres are scattered.

In attempting to draw a comparison between the nervous plexuses, anastomoses, and ganglia, it might be said that in the plexuses there was an exchange of nervous cords, in the anastomoses an exchange of nervous fibres, and in the ganglia an exchange of nervous filaments.

Preparation of the Nerves.

For dissecting the nerves, a very emaciated subject, whether young or old, should be chosen. Old wasted subjects appear to me at least as favourable as young subjects.

The dissection of the spinal nerves is easy. Such is not the case with the cranial nerves, the dissection of which is undoubtedly the most difficult part of practical anatomy. In order to facilitate the study of these nerves, and to aid in the distinction of the nervous filaments from small vessels and portions of fibrous tissue with which they are often confounded, I am in the habit of submitting the head to the action of dilute nitric acid. After having macerated it for some time in this acidulated fluid, I immerse the preparation in pure water which I renew from time to time: the tissues generally as well as the neurilemma become perfectly transparent and like jelly; the nervous matter alone remains whiter and more consistent, and then all error becomes impossible. Besides, the bones, when thus deprived of their phosphate of lime, may be cut like the soft parts. In this way I have succeeded in separating the entire cerebro-spinal nervous system from the other organs, retaining the great sympathetic in connexion with the rest of the nervous system.

DESCRIPTION OF THE NERVES.

General Remarks.—Division into Spinal, Cranial, and Sympathetic Nerves.

The nerves are divided into two very distinct sets: the *cerebro-spinal nerves*, which have their origin or central extremity in the spinal cord or its cranial prolongations: these are the nerves of relation or of animal life; and the *ganglionic nerves* or *nerves of the great sympathetic*, which end in or emanate from certain ganglia: these belong to the system of nutrition or of organic life.

The cerebro-spinal nerves are divided into the *spinal* or *rachidian* and the

* [The grey matter of the ganglia consists, like that of the brain and spinal cord, of reddish nucleated globules, and of grey jointed fibres which surround and adhere to the globules, and which are most abundant in the ganglia of the sympathetic. The white fibres in the ganglia are like those of the nerves with which they are continuous; they interlace amongst the globules, but do not anastomose: it has been supposed that some white fibres may originate or terminate in the ganglia, but this is not established.]

cranial nerves: the first consist of all those which emerge from the intervertebral foramina *; the second, so improperly termed the cerebral or encephalic nerves, emerge from the foramina at the base of the cranium.

As the line of demarcation which seems at first sight to separate the cranium from the spinal column disappears on an analytical study of the skull and on a comparison of it with the vertebræ, so it will be found that the cranial nerves, notwithstanding their apparent irregularity, approach in many respects to the simplicity and regularity of the spinal nerves. From such a comparison of the cranial with the spinal nerves, we shall derive the general principle, that the situation at which the nerves emerge from their osseous cavities is altogether of secondary importance, whilst the fundamental points in their anatomy are the exact situation of their *central extremity*, and their mode of distribution to their peripheral extremity; we shall also find that the only rational basis of a good classification of the nerves must be derived from the consideration of their origin.

In my opinion, the only difference between the cranial and spinal nerves is, that the former arise from the medulla oblongata and its cranial prolongations, whilst the latter arise from the spinal cord below the medulla oblongata. Just as in the osteological division of this work, I have described the vertebra before the cranium, so I shall now describe the spinal before the cranial nerves; this slight modification in the order generally adopted will enable the student to pass from the simple to the complex, and to defer the study of the very complicated nerves of the cranium, until he has been accustomed to the dissection and examination of other nerves.

The following is therefore the order I shall adopt in describing the nerves: the *spinal nerves*, the *cranial nerves*, the *ganglionic or visceral nerves*.

THE SPINAL NERVES.

Enumeration and Classification. — The central extremities or origins of the spinal nerves — apparent origins — deep or real origins. — The Posterior branches of the spinal nerves — common characters — the posterior branches of the cervical nerves, their common and proper characters — the posterior branches of the dorsal, lumbar, and sacral nerves. — The anterior branches of the spinal nerves — their general arrangement.

The number of the *spinal nerves*, that is to say, of the nerves which pass through the intervertebral foramina, including the sacral foramina, is entirely dependent on the number of the vertebræ.†

There are eight pairs (1 to 8, *fig.* 268.) of cervical nerves, including the sub-occipital; twelve of dorsal (9 to 20); five of lumbar (21 to 25); and six of sacral nerves (26 to 31); in all, thirty one pairs.

They all have certain characters in common; and there are also characters proper to certain regions, and lastly characters proper to each nerve.

We shall proceed to examine, under these three points of view, the central extremity, the course, and the termination of the spinal nerves.

The Central Extremities or Origins of the Spinal Nerves.

The Apparent Origins of the Spinal Nerves.

Dissection. The same as that of the spinal cord.

Common Characters.

There are very close analogies, and only slight differences between the different spinal nerves in regard to their origin and course within the spinal canal; this circumstance, added to the fact that the same dissection is re-

* It will be recollected that we have included the sacral foramina among the invertebral.

† This relation between the number of the spinal nerves and the number of the vertebræ prevails throughout the whole series of vertebrate animals; and, accordingly, there are about sixty spinal nerves in certain mammalia, and several hundred in some serpents.

quired to expose the origins of the whole series of spinal nerves, has appeared to me a sufficient reason for including them all in one common description. Such a plan, the object of which is to study analogous parts by comparison, is, infinitely preferable to one in which the origin of each pair of nerves is separately described.

The spinal nerves arise from the spinal cord by a double row of filaments, or by two series of *roots*. These roots are distinguished into the *anterior* (*a a*, *fig.* 267.), which come off from each side of the anterior surface of the cord, and the *posterior* (*b b*), which come off also from each side of the posterior surface. The latter are also named the *ganglionic roots*, because they are more particularly connected with the spinal nervous *ganglia* (*b b*).

The ligamentum denticulatum (*c c*) is situated between these two series of roots.

Immediately after leaving the cord, both the anterior and posterior roots are collected into a number of groups corresponding to the number of the spinal nerves; the nervous cords of which each group consists converge towards each other; the superior cords descending to meet the inferior, which is soon accomplished from the latter being less oblique in their direction. It follows, therefore, that the filaments of each root, situated one above the other, widely separated from each other on the inside, and approximated on the outside, represent a triangle, the general inclination of which to the axis of the cord, varies in each particular region. Not unfrequently the filaments, especially those of the anterior roots, form two secondary groups.

As they are about to enter the separate fibrous canal formed for them by the dura mater, the fibres of each of the anterior roots, and also those of each posterior root, are collected into a flattened cord. There is one fibrous canal for each cord of the anterior roots, and another for each cord of the posterior roots. The arachnoid membrane, which forms a common funnel-shaped sheath for both roots of each spinal nerve, is reflected from them at the points where they enter the fibrous canals of the dura mater, to which the nervous cords are rather firmly attached.

Although the corresponding groups of anterior and posterior roots approach each other to pass through the fibrous canals of the dura mater, there is never the slightest communication between them. It is curious to see the long and numerous cords or filaments which constitute the *cauda equina* running parallel to each other without any anastomoses; whilst as soon as they emerge from the spinal canal, their communications are almost continual.

Communications between the filaments of the same series, whether anterior or posterior, are not rare; they take place in several different ways; thus, sometimes two filaments belonging to the same nerve unite, sometimes the filaments of two different nerves are combined, and at others again a filament intermediate to two nerves bifurcates and is divided between them.

Moreover the oblique direction of the roots of the spinal nerves, and the variable length of their course within the spinal canal, are the necessary consequences of the relative shortness of the cord, which, as it terminates opposite the first lumbar vertebra, cannot give origin to all the nerves opposite the intervertebral foramina, through which they have to pass.*

The *differences* between the anterior and posterior roots may be collected under the following heads: —

The anterior roots arise nearer to the median line than the posterior; they approach nearer and nearer to that line, towards the lower part of the cord, so that in this situation they arise from each side of the median fissure.

Whilst all the posterior roots are given off from a longitudinal furrow of grey substance, from which they never deviate, the anterior roots arise some-

* Gall believed that he had solved this question, by saying that the length and obliquity of the course of the spinal nerves is a necessary result of the erect position of man. It is certain that the nerves are less oblique and have a shorter course within the vertebral canal in the lower animals; but this difference is explained by the greater length of the spinal cord in them, and has nothing to do with the attitude.

what irregularly, and as it were confusedly from a small white column about half a line in breadth.

In regard to size, the posterior roots taken separately are much larger than their corresponding anterior roots; besides this, the filaments of the posterior roots are more numerous, so that the posterior roots taken together are larger than the anterior, as Soemmerring, Chaussier, and Gall have very well established. It is difficult to conceive how some authors should have entertained the opinion, that the proportion between them is just the reverse, at least in some regions; this error has doubtless arisen from the varieties which exist, in different regions of the medulla, in the relative sizes of the anterior and posterior roots, but which are never such as to give the advantage in point of size to the anterior roots: opposite the intervertebral foramina, the series of cords formed by the anterior roots have a different arrangement from those formed by the posterior roots.

The cord formed by each of the posterior roots immediately swells out and forms an olive-shaped ganglion, which is called a *vertebral* or *spinal ganglion* (*b b*, *fig.* 267.). Haase and then Scarpa clearly proved that in general the posterior roots alone passed into the spinal ganglia, and hence they are often denominated the *ganglionic roots:* the spinal ganglia are situated in the intervertebral foramina, those of the sacral region are inclosed in the sacral canal.

Though it is generally to the nervous cord which emerges from this ganglion, that the cord of the anterior root is applied and united, yet I would hasten to observe that the anterior root is not so completely unconnected with the ganglion as is commonly stated; thus, not unfrequently, the fibres of the anterior root are united either to the *outer end* or to the middle of the ganglion. And, moreover, in the lumbar and sacral regions there is half a ganglion on each root.

There are thirty pairs of spinal ganglia, and occasionally thirty-one, when the first pair of cervical nerves or the sub-occipital nerves are provided with them: the size of the ganglia bears no proportion to the diameter of the intervertebral foramina, but depends on the number and size of the filaments of origin which pass into them, and of the nerves which are given off from them.

The cord which emerges from the ganglion is cylindrical, has a plexiform structure, and a furrowed aspect; it is impossible to ascertain what part of it belongs to the anterior and what to the posterior root; it gives off three sets of branches:—the *posterior spinal branches*, which supply the muscles and integuments of the posterior spinal region; the *anterior spinal branches* (see *fig.* 268.), the true continuation of the nerve, which are distributed to the lateral and anterior parts of the trunk and to the upper and lower extremities; and the *ganglionic spinal branches*, which pass to the ganglia of the great sympathetic (*f i u*).

The *ganglionic branches* will be described with the ganglia of the great sympathetic.

As the *posterior branches* have a close analogy in their mode of distribution, and may be exposed in the same dissection, they will be described under one head.

The *anterior branches* being destined for dissimilar parts, their individual distribution is exceedingly varied and complicated, so that a particular description is requisite, if not of the anterior branches of each nerve, at least of those of the several sets of nerves.

Such are the characters common to all the spinal nerves at their central extremities, during their course within the vertebral canal, and at their exit from the intervertebral foramina. Let us next examine the characters proper to the nerves of each region.

Proper Characters of the apparent Origins of the Nerves.

Proper characters of the cervical nerves. The roots of these nerves (1 to 8, *fig.* 268.), are much less oblique than those of the other spinal nerves. The

first cervical nerve slopes a little upwards and outwards, like the cranial veins, which it resembles in this respect. The second nerve is transverse; the succeeding nerves slope downwards and outwards, the lowest being the most oblique; but their obliquity never exceeds the depth of a single vertebra.

The proportion between the size of the posterior and anterior roots is as 3 to 1; and this difference, which is much greater than is observed in any other region, obtains not only in reference to the filaments taken altogether, but also to each particular filament.

The cervical nerves increase rapidly in size from the first to the fifth, and then maintain the same size to the eighth.

The first cervical nerve, so well described by Asch, has some peculiarities; its posterior filaments of origin are much less numerous than the anterior, the spinal accessory of Willis appearing to supply this deficiency; it is also frequently without a ganglion.*

Proper characters of the dorsal nerves. Excepting the first, which has all the characters of the cervical nerves, the roots of the dorsal pairs of nerves (9 to 20) present the following peculiarities: —

A small number of filaments or roots; so that, with the exception of the sacral, the dorsal are the smallest of all the spinal nerves.

Uniformity in the number of the filaments, *i. e.* in the size of their roots. The dorsal nerves are almost of equal size, the twelfth nerve alone being somewhat longer than the rest.

A considerable interval between their roots; and a want of regularity in this interval. Frequently a portion of the spinal cord from eight to ten lines in length gives origin to only a small pair of nerves.

A more marked slenderness of the filaments of origin than in any other region.

The slight disproportion between their anterior and posterior roots when compared filament for filament.

The direction of their roots, which remain in contact with the cord for some distance, and then leave it; this circumstance is calculated to give rise to errors concerning the precise situation of their origin.

The length of their course within the spinal canal; this length is equal to the height of at least two vertebræ.

Proper characters of the lumbar and sacral nerves. The roots of these nerves form the cauda equina; their characters are — the great number of their filaments of origin, which exceeds those of the dorsal and even those of the cervical nerves.

The extreme closeness of these filaments, which form an uninterrupted series.

The proportion between the filaments of the anterior and those of the posterior roots, which is as 2 to 1.

The uniformity in point of size between the two sets of filaments, the anterior filaments, taken individually, being as large as the posterior.

The continuance of the origin of the posterior roots to take place at the groove, whilst the anterior approach nearer and nearer to the median line towards the lower part of the cord, and almost touch those of the opposite side.

The concurrence of both the anterior and posterior roots in the formation of the spinal ganglia.

The almost vertical direction of the roots; a character common to both the lumbar and sacral pairs of nerves.

The singular length of their course before they emerge from the spinal canal. †

* According to the principles of classification which I have already stated, I should range the spinal accessory nerve among the cervical nerves, because it originates from the cervical portion of the spinal cord: in classing it among the cranial nerves I yield to general usage.

† [Lastly, the situation of the ganglia of the sacral nerves within the sacral canal, and of the lowest of them within the cavity of the dura mater.]

The Real Origins of the Spinal Nerves.

The *apparent central extremity* or *origin of the spinal nerves* is very different from their *real central extremity* or *real origin.* On examining the spinal cord of an adult, for the purpose of determining this important point, one is inclined to admit that the point of contact between any nerve and the cord is the real origin of the nerve, so readily can the latter be separated from the cord without leaving any trace of the separation.

It has even been stated by some, that the nerves arise from the neurilemma of the spinal cord.

Chaussier believed that the two series of roots arose from two lateral furrows, one anterior and the other posterior; but Gall has with reason regarded these furrows as formed by pulling off the roots.

Others agree with the older anatomists in regarding the spinal cord as a large nerve formed by the junction of all the nervous filaments which are given off from it. But this idea is refuted by the fact, that the cord does not progressively diminish in size from above downwards, as it must have done if formed by the junction of the roots of the spinal nerves.

The ingenious and correct observation made by Vicq d'Azyr, that the grey matter is always found in large quantity at those parts from which a great number of nerves originate, and that it bears a proportion to the number of these nerves, and the confirmatory observations of Gall and Spurzheim, seem to prove that the nerves originate from the grey matter. This presumption is also strengthened by the consideration, that the central grey substance of the cord is more abundant opposite the posterior roots, which are the larger, than opposite the anterior roots, which are the smaller. On examining the spinal cord of an adult, by means of a stream of water, it is seen that after tearing away the filaments of the nerves, a small conical depression remains where each filament had been attached, and that the real origin of the filaments is not in this depression but is much more deeply seated. This is all that can be discovered from an examination of the spinal cord of the adult; but in the fœtus, at the seventh or eighth month, a considerable part of the cord is semi-transparent, so that the already white filaments by which the nerves arise can be traced into its interior. On making a vertical section transversely through the spinal cord of the fœtus, just level with the commissure, and then directing a strong light on the surface of the section, it will be seen that the great number of very delicate filaments of which the anterior and posterior roots of the spinal nerves are composed, traverse the central grey matter, are arranged like the teeth of a comb, and may be traced into the posterior median columns; these small filaments are, moreover, all parallel. The white commissure might almost be regarded as the commissure of these nerves.

This view is very different from that of Bellingeri, who, entertaining certain physiological ideas, supposes that the anterior as well as the posterior roots of the spinal nerves consist of three sets of filaments, some of which come from the surface of the cord, others from the interior of the white matter, whilst the third set traverse the white matter so as to reach the extremities of the cornua of the grey substance.

Lastly, some anatomists agree with Santorini in believing that the nerves decussate at their origin; but they have not attempted to demonstrate this.

The Posterior Branches of the Spinal Nerves.

Dissection. Divide the integuments from the external occipital protuberance down to the coccyx. Dissect off the skin over the spinous processes with great care, especially opposite the trapezius. Be particularly cautious opposite the cellular interval between the sacro-lumbalis and the longissimus dorsi.

Common Characters.

The *posterior branches of the spinal nerves,* which are generally smaller than

the anterior branches, emanate from the plexiform cords which form the continuation of the corresponding spinal ganglia, are directed backwards, and immediately pass through the foramina which I may regard as *posterior intervertebral foramina.** These branches subdivide into several twigs, which enter the great cellular intervals between the long muscles of the back, and are distributed to the muscles of the integuments. The greatest uniformity prevails among such of these nerves as are distributed to the same kinds of organs, and their differences depend on peculiarities in the parts to which they belong.

We shall now study in succession the posterior branches of the cervical, dorsal, and lumbar spinal nerves.

The Posterior Branches of the Cervical Nerves.

Common Characters.

All the posterior branches of the cervical nerves (*i* to *o'*, *fig.* 300.) pass transversely inwards between the complexus and the semi-spinalis colli, having first given off some very small twigs: having reached the sides of the posterior cervical ligament, they perforate the aponeurotic attachments of the trapezius from before backwards, lie close beneath the skin, and are directed transversely outwards. The course of these branches therefore is at first inwards, and then outwards. The posterior branch of the first cervical nerve is the only one which presents any exception to these general characters.

Proper Characters.

The Posterior Branch of the First Cervical Nerve.

The *posterior branch* of the first cervical or sub-occipital nerve, larger than the anterior branch, escapes between the occipital bone and the posterior arch of the atlas, on the inner side of the vertebral artery with which it is in contact, below the rectus capitis posticus major, and in the area of the equilateral triangle formed by that with the two oblique muscles; in this situation (*i*, *fig.* 300.) it is concealed by a large quantity of fatty tissue which renders it rather difficult of dissection; and it immediately divides into several branches, which may be arranged into the *internal*, which go to the great and small recti muscles; *external*, which supply the great and small oblique muscles; and *inferior* or *anastomotic*, which, by uniting with the second cervical nerve, assist in the formation of the *posterior cervical plexus.*

The branch to the rectus minor passes at first between the rectus major and the complexus and then reaches the rectus minor.

The principal branch for the inferior oblique, before ramifying in that muscle, forms an arch or loop, which has been well described by Bichat.

It follows, therefore, that both of the recti and both of the oblique muscles are supplied by the first cervical nerve, which gives no filament to the complexus †, and none to the skin.

The Posterior Branch of the Second Cervical Nerve.

This is the largest of all the posterior branches of the cervical nerves, and is three or four times larger than the anterior branch of the same nerve; it emerges (*g*, *fig.*.300.) from the spine between the posterior arch of the atlas and the corresponding lamina of the axis, in the same line as the posterior branch of the first nerve, immediately below the lower border of the obliquus major, and is reflected upwards between the hairy scalp on the one hand, and the occipitalis muscle and epicranial aponeurosis on the other; it passes hori-

* Vide OSTEOLOGY (vertebral column in general). These foramina are situated between the tranverse processes, and in the dorsal region are completed on the outside by the superior costo-transverse ligament.

† [Asch saw and has described *a twig* (*m*, *fig.* 300.) proceeding from the posterior branch of the first cervical nerve to the complexus muscle; Swan and Arnold also observed it.]

zontally inwards between the obliquus major and the complexus, perforates this last muscle in the outer side of its digastric portion (the biventer cervicis), then changes its direction, and turns outwards between the complexus and the trapezius through which latter it passes to become subcutaneous and accompany the occipital artery; it is here called the great occipital nerve (occipitalis major; *a*, *fig.* 285.). Hitherto cylindrical, this nerve on becoming subcutaneous is flattened and increased in width, and then passing upwards spreads out into a considerable number of diverging branches, internal, middle, and external, which cover the occipital region with their ramifications, and may be traced even to the parietal region: the internal branches are the shortest and are successively lost in the skin of the occipital region.

It supplies several *branches*, as follows: — *Some anastomotic branches* to the first and third cervical nerves.

Opposite the lower border of the obliquus major, it gives off a considerable *muscular branch* (*w*, *fig.* 300.), which is distributed to that muscle, to the complexus, and especially to the splenius (*w*, *fig.* 298.); the branches to the splenius are of great size, and spread upon its deep surface into diverging twigs, which anastomose both with each other, and with branches derived from the third cervical nerve.

During its passage between the obliquus major and the complexus, and between the last-named muscle and the trapezius, the posterior branch of the second cervical nerve supplies these different muscles with a rather large number of nervous twigs.

Its subcutaneous portion is distributed exclusively to the hairy scalp. The occipitalis muscle, upon which it ramifies, does not receive any branch from it: as we shall elsewhere show, this muscle is supplied by the auricular branch of the facial nerve. The subdivisions of the subcutaneous portion of the second cervical nerve may be traced into the hair follicles, and several of its external branches anastomose with the mastoid branch of the anterior cervical plexus.

The Posterior Branch of the Third Cervical Nerve.

The *posterior branch of the third cervical nerve*, smaller than that of the second, but much larger than that of the fourth nerve, and partially intended for the occipital region, emerges between the transverse process of the atlas and that of the third cervical vertebra, and consequently further outwards than the posterior branches of the first and second nerves; it is immediately curved, and passes transversely inwards (*t*, *fig.* 300.) between the complexus and the semi-spinalis colli. Having reached the inner border of the complexus, it divides into two cutaneous branches — an *ascending* or *occipital*, which perforates the innermost fibres of the complexus, passes vertically upwards upon one side of the median line, applied to the under surface of the skin, and ramifies upon the occipital region, near the median line, and to the inner side of the branch from the second cervical nerve; and a *horizontal* or *cervical branch*, which perforates the aponeurosis of the trapezius between the complexus and the posterior cervical ligament, and passes horizontally outwards beneath the skin, to which it adheres, and in the substance of which it terminates.

As the posterior branch of the third cervical nerve emerges from the posterior intervertebral foramen, it gives off an ascending branch, which forms an anastomotic arch with the descending branch of the second nerve: the succession of arches formed by the anastomoses of the first, second, and third nerves, and the very numerous branches which arise from their convexities, constitute a plexus which may be called the *posterior cervical plexus*: it is situated beneath the complexus, near its external attachments, and it supplies both that muscle and the splenius. The direct anastomoses between the posterior branches of the three superior cervical nerves appear to me to be sometimes wanting; but then the branches given off from them still exist, and form a plexus between the splenius and the complexus.

The Posterior Branches of the Fourth, Fifth, Sixth, Seventh, and Eighth Cervical Nerves.

The *posterior branches of the fourth, fifth, sixth, seventh, and eighth cervical nerves* are much smaller than the preceding, and diminish in size successively from the fourth to the seventh. Immediately after their exit from the posterior intervertebral foramina, they are reflected inwards and downwards in the following manner: the fourth and fifth (*o'*) incline downwards upon the semi-spinalis colli, between it and the complexus; the sixth, seventh, and eighth descend almost vertically beneath the lowest fasciculi of the semi-spinalis colli, supply that muscle and the multifidus spinæ, and having reached the side of the median line, perforate the aponeuroses of the splenius and trapezius, become applied to the skin, and ramify in it.

The Posterior Branches of the Dorsal, Lumbar, and Sacral Nerves.

The posterior branches of the dorsal nerves. These are intended for the dorsal region of the trunk, and resemble each other closely in their distribution, presenting only a few differences connected with the arrangement of the particular muscular layers of each region.

The *posterior branch* of the *first* dorsal nerve has the same muscular and cutaneous relations as the corresponding branches of the lower cervical nerves; it is of the same size, and is distributed in precisely the same manner.

The *posterior branches* of the *second, third, fourth, fifth, sixth, seventh,* and *eighth* dorsal nerves are destined for the thorax, properly so called, and present the greatest uniformity in their size and distribution.

They all emerge from the posterior intervertebral foramina, immediately on the outer side of the semi-spinalis dorsi and multifidus spinæ, and divide into two branches. The *external* or *muscular* branch is directed towards the cellular interval between the sacro-lumbalis and longissimus dorsi, and subdivides into a great number of twigs which are distributed to these two muscles [and to the levatores costarum]. The *internal* or *musculo-cutaneous branch* has a very remarkable course. It is reflected inwards over the semi-spinalis dorsi, embracing the outer border of that muscle, and supplying it with nervous twigs; having reached the side of the spinous process, it is reflected backwards along that process, perforates the spinal attachments of the latissimus dorsi, and thus gains the under surface of the trapezius; in this situation it is reflected outwards between the latissimus dorsi and the trapezius, perforates the latter muscle very obliquely, and becomes subcutaneous; it then passes horizontally outwards in the form of a small nervous ribbon, the distinct fibres of which do not disunite and spread out in the substance of the skin until they have arrived at the scapular region. The cutaneous branch, which belongs to the second dorsal nerve, always corresponds to the triangular surface on the spine of the scapula over which the aponeurosis of the trapezius glides.

In one subject which I examined, the musculo-cutaneous divisions of the posterior branches of the third, fourth, and fifth dorsal nerves presented two ganglia at the point where they bifurcated into their muscular and cutaneous branches; in another, the ganglia were situated upon the cutaneous branches belonging to the first and third dorsal nerves. All these cutaneous branches are horizontal, parallel, and separated from each other by an interval corresponding to the height of one vertebra. Such of the posterior branches of the dorsal nerves as are in relation with the trapezius, always present the preceding arrangement. But the branches lower down than that muscle are distributed in the following manner: —

The *posterior branches* of the *ninth, tenth, eleventh,* and *twelfth dorsal nerves* are distributed in precisely the same way as the *posterior branches* of the *lumbar nerves;* and, like them, are intended for the abdominal parietes.

There is no longer any internal or musculo-cutaneous branch, the external branch representing both the muscular and the cutaneous branch.*

Immediately after emerging from the intervertebral foramina, these posterior branches pass very obliquely downwards and outwards, gain the cellular interval between the sacro-lumbalis and the longissimus dorsi, or rather pass very obliquely through the common mass formed by the union of the sacro-lumbalis and longissimus dorsi, and almost always communicate with each other during their long course through the fleshy fibres: having arrived opposite the outer border of the latissimus dorsi, or of the common mass, these branches, diminished fully one-third, in consequence of having supplied the posterior spinal muscles, perforate very obliquely the aponeurotic layer formed by the union of the aponeuroses of the latissimus dorsi and serratus posticus inferior, with those from the internal, oblique, and tranverse muscles of the abdomen, and become subcutaneous; they then divide into some very small *internal cutaneous filaments*, which are directed inwards upon the side of the spinous processes, and some large *external cutaneous filaments*, which descend to terminate in the skin of the gluteal region. I would especially notice several large nerves, which, either joined together, or only in contact, descend vertically, cross perpendicularly over the crest of the ilium in front of the outer border of the common mass of the lumbar muscles, and become applied to the integuments of the gluteal region upon which they may be traced as far as the great trochanter.

The posterior branches of the lumbar nerves. These resemble in their distribution the corresponding branches of the four lower dorsal nerves; they gradually diminish in size from above downwards; the fifth is extremely small, and is entirely expended in the common mass of the lumbar muscles.

The posterior branches of the sacral nerves. These branches emerge from the posterior sacral intervertebral foramina. It is difficult to dissect them, because they are extremely small, and penetrate immediately into the muscular mass which occupies the sacral groove; they moreover decrease in size from above downwards, and are uniformly arranged in the following manner: immediately after their exit from the posterior intervertebral foramina, they form anastomotic arches with each other, from which muscular and cutaneous filaments are given off. The former are distributed to the common mass and the glutæus maximus; and the latter are intended for the skin of the sacral region.†

The Anterior Branches of the Spinal Nerves.

The *anterior branches of the spinal nerves*, which are generally larger than the posterior, are the true continuations of these nerves, and supply the lateral and anterior parts of the trunk, and also the upper and lower extremities.

Such of these branches as are intended for the trunk of the body have an extremely uniform and very simple mode of distribution; to this class belong the *intercostal nerves:* those, on the other hand, which are intended for the upper and lower extremities, present, in their distribution, a degree of complexity which depends on that of the parts which they supply. To this class belong the *anterior cervical*, *anterior lumbar*, and *anterior sacral branches.*

The three last-named sets of branches almost immediately after their exit from the spinal canal communicate with each other, so as to form interlace-

* [The internal branches of the four lower nerves are not absent, but are much reduced in size, do not reach the surface, and are distributed principally to the multifidus spinæ: the external branches give the cutaneous twigs. (*Demonstrations of Anatomy*, by G. V. Ellis, of whose labours in reference to the anatomy of the nerves, free use has been made in this and many of the succeeding notes.)]

† Among the cutaneous filaments which proceed from the arch formed by the posterior branches of the first and second sacral nerves, there is one which passes below the posterior and inferior spinous process of the ilium, is directed vertically downwards between the glutæus maximus and the lesser sacro-sciatic ligament, perforates the glutæus maximus, and is then reflected outwards in contact with the skin.

ments or *plexuses*, from which are given off the nerves that ultimately ramify in all parts of the body.

There are four great plexuses: two for the region of the neck and the upper extremity, viz. the *cervical plexus* (*x*, *fig.* 268.) and the *brachial plexus* (*h*), which might be regarded as a single plexus, the *cervico-brachial*; and two for the lumbar region and the lower extremity, viz. the *lumbar* (*l*) and the *sacral* or *crural plexus* (*s*), which also might be regarded as one, the *lumbo-sacral plexus.*

After these preliminary observations, I shall now describe, in succession, the anterior branches of the cervical, dorsal, lumbar, and sacral nerves.

THE ANTERIOR BRANCHES OF THE CERVICAL NERVES.

Dissection. — *Anterior branch of the first, second, third, and fourth cervical nerves.* — *The Cervical Plexus* — *its anterior branch, the superficial cervical* — *its ascending branches, the great auricular and the external or lesser occipital* — *its superficial descending branches, the supra-clavicular* — *its deep descending branches, the nerve to the descendens noni and the phrenic* — *its deep posterior branches.* — *The anterior branches of the fifth, sixth, seventh, and eighth cervical, and first dorsal nerves.* — *The Brachial Plexus* — *its collateral branches above the clavicle* — *its muscular branches, posterior thoracic, supra-scapular, opposite to the clavicle the thoracic, below the clavicle, the circumflex* — *its terminal branches, the internal cutaneous and its accessory, the musculo-cutaneous, the median, the ulnar, the musculo-spiral or radial.* — *Summary of the distribution of the branches of the Brachial Plexus.*

Dissection. It is convenient to dissect the subcutaneous branches which emerge from the cervical plexus before examining the anterior branches of the cervical nerves: one side of the neck may be reserved for the superficial, and the other for the deep branches.

The Anterior Branches of the First, Second, Third, and Fourth Cervical Nerves.

The anterior branch of the first cervical nerve. This branch (*u*, *fig.* 300.) emerges from between the occipital bone and the posterior arch of the atlas in the groove for the vertebral artery, and beneath that vessel; opposite the foramen in the transverse process of the atlas, it leaves the artery, passes in front of the base of that process, is reflected downwards, and descends to form an anastomotic arch with the anterior branch of the second nerve. As all the branches belonging to the first nerve come off from this anastomotic arch they will be described with the second nerve.

The anterior branch of the second cervical nerve. This is much smaller than the posterior branch of the same nerve; it passes horizontally forwards between the transverse processes of the atlas and axis, is reflected in front of the axis, and divides into an *ascending* and a *descending* branch.

The *ascending branch* curves upwards in front of the transverse process of the atlas, and anastomoses in an arch with the anterior branch of the first nerve.

The *descending branch* (*z*, *fig.* 298.) subdivides into two others of almost equal size: the one *internal* (see also *fig.* 300.), which constitutes the *internal descending cervical nerve* (before *s*, *fig.* 298.); the other *external* (behind *s*), which anastomoses with the third nerve (above *s*) to form the *superficial cervical nerve* (*k*) and the great *auricular nerve* (*q*).

Several large filaments for the *rectus capitis anticus major* are given off from the angle of bifurcation of the ascending and descending branches.

The anastomotic arch formed by the anterior branches of the first and second cervical nerves gives off three or four very large greyish branches and

several small white filaments, which go to the superior cervical ganglion of the sympathetic; above these it gives a short grey filament which almost immediately swells into a ganglion, from which a long, slender, descending filament proceeds to join the *internal descending nerve;* lastly, it furnishes two ascending filaments, the lower one of which joins the pneumogastric nerve, and the upper one the hypoglossal or ninth nerve.

The anterior branch of the third cervical nerve. This (above *s*, *fig.* 298.) is twice as large as the preceding; it at first passes forwards to emerge from the inter-transverse space, then downwards and outwards, and having gained the under surface of the sterno-mastoid muscle, it expands into a great number of branches, which constitute the cervical plexus properly so called, and may be divided into a *superior* and an *inferior* portion.

The *superior division* passes outwards and backwards beneath the sterno-mastoid muscle, and bifurcates upon its posterior borders. One of the branches of the bifurcation ascends and is called the *mastoid nerve* (*y*); the other, which is reflected over the posterior border of the muscle, anastomoses by one or two filaments with the anterior branch of the second cervical nerve, and subdivides into the *superficial cervical nerve* (*k*) and the *auricular nerve* (*q*): both of the branches of the bifurcation anastomose with the second cervical nerve. This superior division, moreover, gives off a small nerve, which ascends between the auricular and mastoid nerves; also a communicating branch to the superior cervical ganglion; and, lastly, a series of branches (*v*), which anastomose with the spinal accessory nerve of Willis (*t*), some immediately, and others whilst within the substance of the sterno-mastoid muscle. This superior division of the third nerve sometimes joins the lowest branch of the second nerve.

The *inferior* or *descending portion* passes vertically downwards in front of the scalenus anticus, gives off a long slender filament to the *internal descending cervical nerve*, and terminates partly by anastomosing with the fourth cervical nerve (below *s*), and partly by becoming continuous with the clavicular nerves (*u*).

A considerable branch which enters the levator anguli scapulæ may be regarded as belonging to this inferior portion. This branch for the angularis sometimes arises at the point of bifurcation of the anterior branch of the third nerve.

The anterior branch of the fourth cervical nerve. This branch (below *s*) is of the same size as the preceding; it gives off the *phrenic nerve* (*l*), which sometimes arises in the inter-transverse space: it then passes downwards and outwards in contact with the scalenus anticus for about ten lines, and divides into two terminal branches, the one internal, the other external, which soon subdivide and cover the supra-clavicular triangle with their diverging ramifications: these branches constitute the *supra-clavicular* and *acromial* nerves (*u*). Just opposite its division the anterior branch of the fourth cervical nerve receives a branch from the third, which appears to be shared between its two terminal divisions.

The fourth cervical generally sends off a small communicating branch to the fifth cervical nerve.

The Cervical Plexus.

The term *cervical plexus* is applied to the series of anastomoses (*z s*) formed by the anterior branches of the first, second, third, and fourth cervical nerves.

Some anatomists call it the *deep cervical plexus*, in contra-distinction to the superficial branches given off from it, which, according to this view, constitute the *superficial cervical plexus.*

This plexus, which occupies the anterior and lateral aspect of the four superior cervical vertebræ, is situated beneath the posterior border of the sterno-cleido-mastoid muscle, to the outer side of the internal jugular vein, between the rectus capitis anticus major and the cervical attachments of the splenius and levator anguli scapulæ: it is concealed by a considerable quantity of fat,

and by a great number of lymphatic glands: it is also covered by an aponeurotic lamina, which adheres to it intimately, and is prolonged upon the nerves which emanate from it.

After the example of Bichat, this plexus may be regarded as a centre in which the anterior branches of the four superior cervical nerves terminate, and from which a great number of branches proceed. This plexus is by no means inextricable; it is always easy to determine the origin of the branches which come from it.

These branches consist of one anterior branch, the *superficial cervical* (*k*); of ascending branches, viz. the *great mastoid* (*y*), the *small mastoid*, and the *great auricular* (*q*); and of descending branches, subdivided into the deep and the superficial; the deep ones consisting of the *internal descending branch* (before *s*), the *phrenic* nerve (*l*), and the *branches for the trapezius, levator anguli scapulæ*, and *rhomboideus;* the superficial descending branches are the *supra-clavicular* and the *acromial* (*u*).

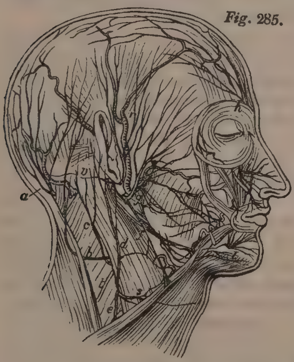
According to their distribution, they may also be divided into *muscular* and *cutaneous* branches; the muscular consist of the internal descending, the phrenic, the branches for the trapezius, the levator anguli, and the rhomboideus; all the others are cutaneous, and are flattened like ribbons.

The Anterior Branch.

The Superficial Cervical Nerve.

The *superficial cervical nerve* (superficialis colli; *s*, *fig.* 285.), which is often double, in consequence of dividing earlier than usual, is destined exclusively for the skin of the neck and lower part of the face (sous-mentonnière, *Chauss.*) and is formed by the anastomoses of the second and third cervical nerves; it emerges from the plexus opposite the middle of the neck, beneath the posterior border of the sterno-mastoid, around which it turns in the form of a loop, and then passes horizontally forwards between that muscle and the platysma, runs at right angles beneath the external jugular vein, and divides into two branches — one *ascending* and larger, the other *descending;* these two branches often form two distinct nerves.

Fig. 285.



The *descending branch* passes downwards and inwards between the sterno-mastoid and the platysma, is reflected upwards so as to form a loop, having its concavity turned upwards, perforates the platysma, and then lies in contact with the skin beneath which it may be traced as far as opposite the os hyoides.

One of its twigs, which appears to me to be constant, having reached the side of the median line, is reflected upwards in front of the anterior jugular vein, ascends vertically, and may be traced into the skin of the supra-hyoid region.

The *ascending branch*, which sometimes arises by a common trunk with the auricular nerve, immediately divides into four or five very slender and slightly waving filaments, which, situated at first between the sterno-mastoid and the platysma, generally perforate the last-named muscle to become subcutaneous: two of these diverging filaments, which remain subjacent to the platysma, are very slender and run along the external jugular vein, one in front of and the other behind that vessel.

All the other filaments pass upwards and inwards in contact with the skin, and subdivide into a great number of filaments which may be traced as far as

the skin of the chin and lower part of the cheek; I have seen two of these filaments anastomose with the facial nerve. It is important to observe that the cervical filaments of the facial nerve occupy a deeper plane than those of the superficial cervical nerve, and are separated from these latter in front by the platysma.

The Ascending Branches.

The Auricular Nerve.

The *auricular nerve* (auricularis magnus; *d, fig.* 285.), the ascending anterior branch of the cervical plexus, arises from the second and third cervical nerves by a trunk which is common to it and to the superficial cervical; it emanates from the plexus immediately above the last-named nerve, like which it embraces the posterior border of the sterno-mastoid so as to form a loop with the convexity turned backwards, and then passes upwards and a little forwards between the platysma and the sterno-mastoid, and reaches the anterior border of that muscle opposite the angle of the lower jaw. In this situation it gives off several *facial* or *parotid* filaments, and terminates by dividing into a *superficial* and a *deep* branch.

The *facial* or *parotid branches* are very slender; some of them pass between the parotid and the skin with which they are in contact; the others pass through the parotid gland from behind forwards, and from below upwards, to be distributed to the skin of the cheek; I have traced them as far as the skin which covers the malar bone; it has not been shown that some of them terminate in the substance of the parotid as has been stated.*

The *superficial auricular branch* ascends vertically, in the substance of the very dense fibrous tissue which connects the parotid to the skin; it gains the lower part of the concha opposite to the anti-tragus, and then divides into several filaments, the distribution of which is remarkable: the largest passes above the lobule in the fissure between the concha and the caudal extremity of the helix, and is distributed to the skin on the concave surface of the auricle, and especially to the skin of the concha; another filament turns round the margin of the auricle, and gains the groove of the helix which it follows even to its upper part.

The *deep auricular branch*, which may be called the *anterior mastoid*, perforates the substance of the parotid gland, and gains the front of the mastoid process; here it crosses at an acute angle over the auricular branch of the facial nerve, which is more deeply seated, and with which it anastomoses by a rather large branch; it then passes behind the posterior auricular muscle, and divides into two secondary branches — a *posterior*, which passes upwards and backwards, and may be traced as far as the outer border of the occipitalis muscle, where it anastomoses with a very delicate filament of the external occipital nerve; and an *anterior*, which runs upon the upper part of the cranial surface of the auricle. The superior filaments are reflected over the upper margin of the auricle and are distributed to the skin which covers its external or concave surface.

From what has been just stated it follows, that the auricularis magnus gives off no muscular filament. The posterior auricular and occipitalis muscles are supplied entirely from the auricular branch (v) of the facial nerve.

The Mastoid or External Occipital Nerve.

The *mastoid* or *external occipital nerve* (occipitalis minor, b), the posterior ascending branch of the cervical plexus, rises from the second cervical nerve; it comes off from the plexus above the preceding nerve, describes a loop with

* I have seen two of these parotid filaments terminate in a small abnormal ganglion, from which other filaments were given off and distributed in the manner above described.

the concavity turned upwards upon the posterior border of the sterno-mastoid, ascends almost vertically, parallel to the great occipital nerve and to the posterior border of the sterno-mastoid, crosses the posterior occipital attachments of that muscle, continues to ascend upon the occipital region, and then upon the parietal region, and may be traced as far as opposite the anterior border of the parietal bone. During this course it is situated between the splenius and occipitalis muscles and epicranial aponeurosis on the one hand, and the skin on the other.

This nerve gives off in the occipital region:—some *external branches*, which are distributed to the skin, and anastomose with a filament of the auricular nerve, but none of them pass to the auricle. The term *occipito-auricular* (*Chauss.*) is therefore not applicable to it; it should rather be called the *external occipital* (occipitalis minor, *b*) *, to distinguish it from the *internal occipital*, (occipitalis major, *a*), given off by the posterior branch of the second cervical nerve.

It also supplies some *internal branches*, which anastomose several times with the internal occipital nerve, and are distributed to the skin.

It gives no filament to the occipitalis muscle, nor does it anastomose with the facial nerve. The mastoid or external occipital nerve is essentially a cutaneous nerve.

We sometimes find a small supplementary branch between the great auricular and external occipital nerves, which runs parallel to them, and may be called the *small mastoid nerve* (*c*).

The Superficial Descending Branches.

The Supra-clavicular Nerves.

The supra-clavicular nerves (*e*, *fig.* 285.; *u*, *fig.* 298.). The terminating branches of the cervical plexus are two in number: one internal, or the *supra-clavicular nerve*, properly so called; the other external, or the *acromial nerve*; they come off from the plexus at the posterior border of the sterno-mastoid, descend perpendicularly towards the clavicle, and divide into several branches, which again subdivide before reaching that bone, so that they cover the supra-clavicular triangle with their diverging filaments. All these branches cross over the clavicle at almost regular intervals, and are lost upon the upper and anterior part of the thorax.

The innermost or *sternal branches* cross very obliquely over the external jugular vein, then over the clavicular and sternal attachments of the sterno-mastoid, and ramify in the skin, where they may be traced as far as the median line.

The external or *acromial branches* pass obliquely over the external surface of the trapezius, cross the outer end of the clavicle, and are distributed to the skin over the acromion and the spine of the scapula. I have followed some filaments over the top of the shoulder as far as the lower borders of the pectoralis major.

The intermediate or *clavicular* branches cross the clavicle at right angles, are in contact with the skin upon the upper part of the thorax, and may be traced to within a short distance of the nipple.†

All these branches lie at first beneath the platysma, and then become subcutaneous. A layer of fascia and the omo-hyoid muscle are interposed be-

* The name mastoid branch is bad, for this branch has no relation with the mastoid process.

† Not unfrequently the supra-clavicular nerve passes through a foramen in the clavicle, at the junction of the external third with the internal two thirds of that bone; sometimes, instead of a bony canal, there is a tendinous arch upon the posterior border of the bone. In this case the clavicular branches are not scattered, but closely aggregated together; the internal branches then pass horizontally inwards between the clavicle and the skin as far as the sternum; and I have even seen a small twig enter the attachments of the pectoralis major. The external branches proceed horizontally outwards upon the anterior border of the clavicle as far as the acromion.

tween them and the scaleni muscles and brachial plexus. Some loose cellular tissue separates them from the clavicle, upon which they glide with the greatest freedom.

The Deep Descending Branches.

The Internal Descending Cervical Nerve.

The *internal descending cervical nerve* (before *s*, *fig.* 298.), which is destined exclusively for the muscles of the sub-hyoid region, may be considered as the inferior branch of the bifurcation of the second cervical nerve, although the first and third nerves each give to it a small reinforcing filament.

It passes vertically downwards, on the outer side of the internal jugular vein, along which it runs, is joined on its inner side by a filament from the first cervical nerve, and having reached a little below the middle of the neck, is reflected inwards in front of the internal jugular vein, and forms an anastomotic loop which is sometimes plexiform, with the descending branch (descendens noni, *h*) of the hypoglossal nerve; this is a remarkable anastomosis, and presents many varieties in its arrangement. The convexity of this loop is turned downwards, and from it arises a branch which sometimes scarcely exceeds in size either of the formative branches of the loop, and which expands into several filaments (*g*). One of these ascends and supplies the superior attachments of the sterno-hyoid and omo-hyoid; a transverse filament proceeds to the bodies of the sterno-hyoid and sterno-thyroid muscles. Several filaments can be traced as far as the lower part of the latter muscle, that is to say down to opposite the second rib. The inferior fleshy belly of the omo-hyoid is supplied by some twigs derived from the filaments which enter its superior belly.

The Phrenic or Diaphragmatic Nerve.

The *phrenic nerve* (*l*, *fig.* 298. 302.) is a branch derived from the fourth cervical nerve, sometimes reinforced by a very small filament from the third nerve, and almost always by a larger branch from the fifth.* Not unfrequently one of the formative branches of the loop of the hypoglossal nerve just described joins the phrenic nerve. The right and left phrenics are rarely of the same size.

After its origin, the phrenic nerve descends vertically in front of the inner border of the scalenus anticus, with which it is held in contact by a fascia. It is round at first, but becomes flattened as it passes between the subclavian vein and artery (I have seen it pass in front of the vein), and is then inclined slightly inwards, to enter the superior orifice of the thorax. In the thorax, (*l*, *fig.* 302.) it continues its vertical direction, runs along the brachio-cephalic vein on the left side, and along the vena cava superior on the right side, is then applied against the pericardium, to which it is bound down by the pleura, and, having reached the diaphragm, ramifies in that muscle. It is accompanied by the superior phrenic artery, which is a branch of the internal mammary, and the superior phrenic vein.

The phrenic nerve gives off no branches in the thorax: at a short distance from its origin, it anastomoses with the great sympathetic by a transverse branch: at the lower part of the neck, it sometimes gives off a filament, which form an anastomotic arch with a branch derived from the fifth and sixth cervical nerves. I have never seen it communicate with the inferior cervical ganglion.

The distribution of this nerve in the diaphragm is curious. Some of its expanded, diverging, and generally very long, filaments, run between the pleura

* The communication between the phrenic nerve and the fifth cervical nerve occurs in many different modes. Sometimes the phrenic supplies the communicating filament, instead of receiving it; most commonly the phrenic branch of the fifth arises by a common trunk with the nerve for the subclavius muscle, crosses in front of the subclavian vein, between it and the cartilage of the first rib with which it is in contact, and passes behind the internal mammary artery to join the phrenic nerve at a very acute angle.

and the diaphragm, and enter the muscle from its upper surface; others pass through the diaphragm, run between it and the peritoneum, and enter the fleshy fibres from below; they may be traced as far as the costal attachments of the muscle. The right phrenic nerve terminates by a transverse branch which passes behind the vena cava, and anastomoses with certain transverse branches of the left phrenic, before it enters the pillars of the diaphragm in which it terminates. I have never seen any filament of the phrenic nerve pass either to the œsophagus or to the solar plexus.

The Posterior Deep Cervical Branches.

These are:—an *anastomotic branch* (*v*, *fig.* 298.) from the cervical plexus to the spinal accessory nerve of Willis (*t*); it is of considerable size; it comes off from the second nerve at the same point as the external occipital nerve, and anastomoses at an acute angle with the spinal accessory, between the cervical fasciculi of the splenius and the sterno-mastoid.

Also, *a branch for the trapezius*, which arises from the third nerve, passes obliquely downwards and backwards to the deep surface of the muscle, and anastomoses with the spinal accessory of Willis, which it reinforces, and with which it may be traced as far as the lower angle of the muscle.

Lastly, the *branches for the levator anguli scapulæ* and the *rhomboideus*; these are rather small branches, which arise from the back part of the third and fouth cervical nerves, as they emerge from between the transverse processes of the vertebræ, pass obliquely downwards and backwards, turn round the scalenus posticus in contact with it, and are distributed to the levator anguli scapulæ and the upper part of the rhomboideus. The same branches appear to supply both muscles.

The Anterior Branches of the Fifth, Sixth, Seventh, and Eighth Cervical and First Dorsal Nerves.

These branches are remarkable for their size, in which respect they surpass the preceding, and are almost all equal. On emerging from the intervertebral foramina, they come into relation with the two scaleni muscles, which are separated from each other and sometimes are perforated by them; they give off some very slender filaments to these muscles, and, converging, anastomose together so as to form the *brachial plexus*, from which all the nerves of the upper extremity are derived.

The Brachial Plexus.

The *brachial plexus* (*h*, *fig.* 268.) extends obliquely from the lateral and inferior part of the neck to the cavity of the axilla, or rather to the inner side of the head of the humerus, where it terminates by dividing into the nerves of the upper extremity; it is formed in the following manner:—

The fifth and sixth cervical nerves (5, 6, *fig.* 286.) unite at a short distance from the scaleni, and the cord thus formed passes very obliquely downwards and outwards, and then *bifurcates*.

Again, the eighth cervical (8) and the first dorsal (1) nerves unite immediately after converging from the scaleni, and sometimes even between those muscles; and the common cord passes almost horizontally outwards, and *bifurcates* near the head of the humerus.

Between these two anastomotic cords is the seventh cervical nerve (7), which pursues a much longer course than the others, and *bifurcates* on a level with the clavicle; the upper branch of its bifurcation joins the lower branch of the bifurcation of the first named cord, and its lower branch unites with the upper branch of the second named cord.

From these several bifurcations and subsequent anastomoses, all of which

take place at very acute angles, results the interlacement known as the *brachial plexus.*

The brachial plexus is broad at its upper part, contracted in the middle, and broad again at its lower part, on account of the divergence of its terminating branches; it communicates with the cervical plexus by a considerable branch which it receives from the fourth cervical nerve, and also by the filament which it gives to the phrenic nerve; it is not so complicated but that the origins of the branches which emanate from it may be traced; I shall take care to do this for each nerve.

Relations. At its origin it is situated between the scaleni, which cover it for a greater extent below than above. A very strong aponeurosis, which extends over it and the scaleni also, completely isolates it from the surrounding parts.

Lower down, it is situated between the clavicle and subclavius muscle on the one hand, and the first rib and upper part of the serratus magnus on the other.

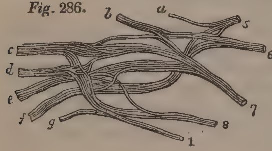
Still lower, it is contained in the cavity of the axilla, separated from the pectoralis major in front by the costo-clavicular aponeuroses, and resting upon the scapulo-humeral articulation behind, from which it is separated by the tendon of the sub-scapularis.

The following are its relations with the *axillary artery :*— Between the scaleni and below them, the artery is situated upon the same plane as the brachial plexus, and lies between the plexus and the first rib. Lower down it is placed on the anterior part of the plexus; at the lower extremity of the plexus it passes under the angle of union of the two roots of the median nerve by which it is embraced; the axillary vein always lies in front of the artery, and therefore has less direct relations with the plexus.

The branches of the brachial plexus may be divided into the *collateral* and the *terminal.*

The *terminal branches* are five in number, namely, the *internal cutaneous* (*g*, *fig.* 286.) and its *accessory*, the *musculo-cutaneous* (*b*), the *median* (*c*), the *radial* or musculo-spiral (*f*), and the *ulnar* (*d*) nerves.*

Fig. 286.



The *collateral branches* may be divided into — those given off above the clavicle, namely, the nerve for the *subclavius*, those for the *levator anguli scapulæ* and *rhomboideus*, the *posterior thoracic* or *nerve for the serratus magnus*, the *supra-scapular nerve* (*a*) or *nerve for the supra- and infra-spinati muscles*, and the *superior subscapular nerve;* those given off opposite the clavicle, namely the *thoracic branches;* and those given off in the axilla, namely the *circumflex nerve* (*e*) and the *subscapular branches*, which comprehend the *nerve for the latissimus dorsi*, the *nerve for the teres major* and the *inferior scapular nerve.*

One branch only, namely the nerve for the subclavius muscle, arises from the front part of the brachial plexus : all the other collateral branches are given off from the back of the plexus.

The Collateral Branches of the Brachial Plexus.

The Branches given off below the Clavicle.

The nerve for the subclavius muscle. This is a small but constant branch, which comes off from the fifth cervical nerve, immediately before its junction with the sixth, passes vertically downwards in front of the subclavian artery, and then enters perpendicularly into the middle of the subclavius muscle.

* I think it right to class the circumflex nerve among the collateral branches, and not, like most authors, among the terminal branches of the plexus.

This small nerve, before reaching the subclavius, always gives off a *phrenic branch*, which passes obliquely inwards in front of the subclavian vein and anastomoses with the phrenic nerve.

The nerve for the levator anguli scapulæ. This branch arises as frequently from the cervical as from the brachial plexus; in the former case, it arises from the fourth cervical nerve, in the latter from the fifth. It arises from the nerve immediately after its exit from the canal of the transverse processes, turns round the scalenus posticus to gain the deep surface of the levator anguli scapulæ, enters the muscle, supplies it with a great number of filaments, and perforates it to reach the rhomboideus under which it passes. One of its terminating filaments anastomoses with a filament from the proper nerve for the rhomboideus.

The nerve for the rhomboideus. This arises from the fifth cervical nerve immediately below the preceding; I have seen it arise by a common trunk with the superior branch of origin of the nerve for the serratus magnus; it passes downwards and backwards between the scalenus posticus and the levator anguli scapulæ, and then beneath the last-mentioned muscle, nearly as far as its scapular attachments, in order to get between the rhomboideus and the ribs; it may be traced as far as the lower part of that muscle. One of its filaments perforates the rhomboideus, and anastomoses in the trapezius with the posterior spinal nerves.

The nerve for the serratus magnus (*posterior thoracic nerve*, of authors, *external respiratory nerve*, Sir C. Bell). This branch, which is very remarkable for the length of its course, is derived from the fifth and sixth cervical nerves, immediately after their exit from the canal of the transverse processes; it arises by two roots, which are sometimes equal, and sometimes unequal in size; it passes vertically downwards behind the brachial plexus and the axillary vessels, in front of the scalenus posticus, reaches the side of the thorax (*e′*, *fig.* 287.) between the subscapularis and the serratus magnus, runs the whole length of the last-named muscle, and ramifies in its lower portion.

During this course, it gives off a great number of filaments to the muscle: the lowest of these may be traced as far as the lowest digitation. The branch which it gives to the upper part of the muscle is remarkable for its size.

I have seen a branch from the seventh cervical nerve join the external thoracic nerve upon the upper part of the serratus magnus, so that this nerve would then be derived from the fifth, sixth, and seventh cervical nerves.

The supra-scapular nerve, or nerve for the supra- and infra-spinati muscles. This branch (*a*, *fig.* 286.) is given off from the back part of the fifth cervical nerve at its junction with the sixth; it passes obliquely backwards, outwards, and downwards, dips beneath the trapezius, and then under the omo-hyoid, the direction of which it nearly follows, and gradually increases in size as it approaches the coracoid notch of the scapula, and passes by itself under the ligament which converts this notch into a foramen; the supra-scapular artery and vein, which had hitherto been in contact with the nerve, leave it opposite this notch to pass above the ligament, and then join it again in the supra-spinous fossa.

The nerve then runs from before backwards in the supra-spinous fossa, protected by a thick fibrous lamella, reaches the free concave border of the spine of the scapula, against which it is held by a fibrous band, is then reflected inwards and downwards over this concave border to gain the infra-spinous fossa, and immediately divides into two branches, one of which spreads out in the upper part, and the other in the lower part of the infra-spinatus muscle.

During its course through the supra-spinous fossa, the supra-scapular nerve gives off two supra-spinous branches, one of which is detached opposite the coracoid notch, and the other upon the spine of the scapula. They both enter the supra-spinatus muscle.

The supra-scapular nerve is exclusively destined for the supra- and infra-spinati muscles. It gives no filament to the subscapularis.

The superior subscapular nerve. This is a very small branch which arises immediately above the clavicle, and passes downwards and forwards to reach the upper border of the subscapularis, and then enters that muscle.

The Branches given off opposite to the Clavicle.

These, which are named the *thoracic branches**, are generally two in number, one *anterior*, the other *posterior*: they arise from the anterior part of the brachial plexus, opposite the subclavius muscle. The *anterior branch*, or *nerve for the pectoralis major*, which is the larger, passes downwards and forwards between the subclavius muscle and the subclavian vein, and divides into two branches—an *external*, or anastomotic, which sometimes arises directly from the brachial plexus, and forms a loop around the axillary artery, by anastomosing with the posterior thoracic branch; and an *internal*, which runs along the deep surface of the pectoralis major, and expands into a great number of remarkably long and slender filaments, which enter the muscle very obliquely, and may be traced as far as its sternal attachments. A very slender filament is constantly found running along the clavicle.

The *posterior thoracic branch*, or *nerve for the pectoralis minor*, passes behind the axillary artery, below which it curves forwards to form, with the external branch of the anterior thoracic, the anastomotic loop of which I have already spoken. From this loop or arch, in forming which the nervous filaments are separated from each other, two sets of branches proceed: the one set runs between the pectoralis major and minor, closely applied to the former muscle, which they then enter, diverging to its lowest part; the others pass beneath the pectoralis minor, and penetrate its deep surface; some of them pass obliquely through this muscle and join the anterior thoracic branches in the pectoralis major.

The Branches given off below the Clavicle.

The axillary or circumflex nerve. This is no less remarkable for its great size, which has led some anatomists to regard it as a terminal branch of the brachial plexus, than for its reflected course: it comes off from the back of the plexus, behind the musculo-spiral nerve; or rather, the circumflex and musculo-spiral nerves (*e* and *f*, *fig.* 286.) appear to be the two divisions of a trunk formed by filaments from the five branches of the brachial plexus.

Immediately after its origin, the circumflex nerve passes downwards and outwards (*g*, *fig.* 288.) in front of the subscapularis, which separates it from the shoulder joint, turns obliquely round the lower border of that muscle, round the back part of the articulation, and lastly round the surgical neck of the humerus, is then reflected upwards so as to describe a curve with the concavity turned in the same direction, and terminates by ramifying in the deltoid.

During this curved course, the circumflex nerve, accompanied by the posterior circumflex vessels, passes at first between the subscapularis and the teres major, then below the teres minor, on the outer side of the long head of the triceps (*i. e.* next to the bone), and then lies in contact with the deep surface of the deltoid, against which it is held by a very dense layer of fascia.

The relation of the circumflex nerve to the articulation explains the possible occurrence of laceration of this nerve in luxations of the humerus downwards.

The *collateral branches of the circumflex nerve* are three in number. One branch almost always goes to the subscapularis. I have already said that the subscapular nerves might be regarded as branches of the circumflex.

As it turns round the lower border of the subscapularis, the circumflex gives off a *branch for the teres minor* and the *cutaneous branch of the shoulder*.

* The anterior thoracic nerves of those who name the nerve for the serratus magnus the posterior thoracic.

The *nerve for the teres minor* enters that muscle by its lower border; it almost always arises by a common trunk with a deltoid branch, which runs upwards and backwards to supply the back part of the deltoid muscle.

The *cutaneous nerve of the shoulder* frequently arises by a common trunk with the two preceding, and in this case the circumflex nerve appears to bifurcate; it passes under the posterior border of the deltoid, then lies in contact with the skin covering the back part of the top of the shoulder, and divides into diverging branches, some ascending, others descending, and others running horizontally. A second, and sometimes a third, cutaneous branch, perforates the fleshy fibres of the deltoid, and is distributed to the corresponding skin.

The *terminal* or *deltoid branches of the circumflex nerve* are given off as that nerve is turning round the neck of the humerus, in which situation it divides into several diverging branches, the superior of which *ascends* and appears like the continuation of the nerve, whilst the others *descend* and may be traced as far as the insertion of the muscle into the humerus.

The subscapular nerves. The *nerve for the latissimus dorsi* is the largest of the nerves generally described as the *subscapular*; it comes off at an acute angle from the inside of the circumflex nerve, and descends vertically in the midst of the cellular tissue of the axilla, between the subscapularis and serratus magnus, parallel to the external thoracic nerve, which it greatly resembles in size and direction as well as in its length, it then passes in front of the latissimus dorsi, reaches its outer border, and may be traced down to the lower part of that muscle.

The *nerve for the teres major* arises at a very acute angle from the preceding nerve, to the inner side of which it runs; it passes to the subscapularis, turns round its outer border, and enters the anterior surface of the teres major by a great number of filaments.

The *inferior subscapular nerve* (*l*, *fig.* 288.) is sometimes multiple, and presents many varieties in its origin and number. Thus, it sometimes curves directly from the brachial plexus; sometimes from a common trunk with the circumflex nerve. Again, it often arises by a common trunk with the nerve for the teres major. Whatever be its origin, and whether it be single or multiple, it enters immediately into the subscapularis, and terminates there.

We have seen that a small branch given off from the brachial plexus above the clavicle, the *superior subscapular nerve*, enters the same muscle at its upper border.

The Terminal Branches of the Brachial Plexus.

The Internal Cutaneous Nerve and its Accessory.

The *internal cutaneous nerve* (*g*, *fig.* 286.), the most internal and the smallest of the terminal branches of the brachial plexus, arises by a common trunk with the ulnar nerve (*d*) and the internal root of the median (*c*): concealed at first by the axillary artery, it descends vertically (*a*, *fig.* 288.) to the inner side of the median nerve, and in front of the basilic vein: at the upper part of its course it lies beneath the fascia, but it becomes subcutaneous at the same time as the basilic vein (*b*, *fig.* 287.), and is then separated from the median nerve by the brachial aponeurosis; at the middle of the arm, it divides into two terminal branches, an *external*, *anterior* or *ulnar*, and an *internal*, *posterior* or *epitrochlear*.

The internal cutaneous gives off only one branch during its course along the arm, namely, a *cutaneous branch*, which varies in size as well as in the situation at which it is given off: this cutaneous branch arises in the cavity of the axilla, often anastomoses with an intercostal nerve, is applied against the skin on the inner aspect of the arm, and may be traced as far as the elbow.*

* I have always found a remarkably long and slender filament arising from the internal cutaneous nerve at the upper part of the arm; it runs along that nerve, passes beneath the basilic

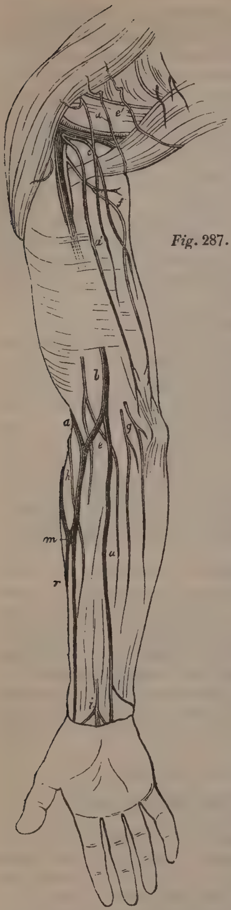


Fig. 287.

Terminal branches. The *anterior, external* or *ulnar branch*, which is the larger, continues in the vertical direction of the trunk of the nerve, and divides into two branches, which descend in front of the elbow joint, sometimes before, and sometimes behind the median basilic vein (*e*), and again subdivide into a great number of filaments which diverge, and are arranged in the following manner: the internal filaments pass obliquely downwards, inwards, and backwards, crossing the ulnar vein (*u*), and then the ulna, and supply the skin covering the inner and back part of the fore-arm; they can be traced nearly as far as the region of the carpus: the external filament, which might be called median, because it follows the median vein, descends vertically, and may be traced as far as the upper part of the palm of the hand; one of these filaments always anastomoses with a twig from the ulnar nerve at the lower part of the fore-arm.

The *posterior, internal* or *epitrochlear branch* (*g*), descends vertically behind the median basilic vein, in front of the epitrochlea, and then below it, so as to embrace it in a sort of loop; it then passes very obliquely downwards and backwards, crosses the ulna below the olecranon, gains the dorsal aspect of the fore-arm, and runs vertically (*a, fig.* 289.) down to the wrist. Around the epitrochlea, this internal branch gives off several branches, which ramify upon the skin that covers the inner side of the elbow joint: one of these branches is reflected upwards between the epitrochlea and the olecranon, and anastomoses with the accessory nerve of the internal cutaneous. Frequently, before reaching the epitrochlea, this branch has already given off a twig which anastomoses with the same nerve.

Summary. The *internal cutaneous nerve*, then, is exclusively intended for the skin. It only gives one small branch to the arm: its other divisions are intended for the fore-arm. One of them belongs to the dorsal, and the other to the internal aspect.

The *accessory nerve of the internal cutaneous.* I have applied this term to a small branch (cutaneus minor internus, *Wrisberg*,) which it is difficult to discover, and which would be more properly classed among the collateral than the terminal branches of the brachial plexus: it arises above and sometimes below the clavicle, from the back part of the nervous cord formed by the junction of the eighth cervical and first dorsal nerves: it passes downwards upon the sides of the thorax, and divides into two branches, an *external* and an *internal*.

The *external branch* (*a'*, *fig.* 287.), which is the smaller one, passes vertically downwards, and crosses the conjoined tendons of the teres major and latissimus dorsi at right angles; it lies in contact with the skin covering the inner and back part of the arm, and may be traced as low as the elbow.

The *internal branch* (*c*) anastomoses with the second intercostal nerve, de-

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vein, and then lies in contact with the fascia, which it perforates near the epitrochlea, and is lost upon the synovial membrane of the elbow joint.

scends vertically, crossing the conjoined tendons of the latissimus dorsi and teres major, becomes applied to the skin, and divides into several very slender filaments, which correspond to the internal, anterior, and posterior regions of the arm, and may be traced as far as the region of the elbow; one of these filaments anastomoses with the internal cutaneous.*

The Musculo-cutaneous Nerve.

The *musculo-cutaneous nerve* (*b*, *fig.* 286.), the most external of the terminal branches of the brachial plexus, and, with the exception of the internal cutaneous, the smallest, arises by a common trunk with the external root of the median nerve (*c*), passes downwards and outwards, in front of the humeral insertion of the subscapularis, and on the inner side of the coraco-brachialis, which is perforated by it, and is therefore called the *perforated muscle of Casserius.*† After emerging from the muscle, through which it passes very obliquely‡, the musculo-cutaneous nerve (*h*, *fig.* 288.) is situated between the biceps and the brachialis anticus, continues its oblique course, escapes from beneath the outer border of the tendon of the biceps, and then becomes subcutaneous.

During its course along the arm it gives off the following branches:

The *branches for the coraco-brachialis* are two in number, one *superior*, which enters the upper part of this muscle, and is then lost in the short head of the biceps; the other *inferior*, which, in some subjects, after having furnished a certain number of filaments to the coraco-brachialis, becomes applied to the trunk of the musculo-cutaneous nerve itself.

The *branches for the biceps* are very numerous: not uncommonly they arise by a common trunk, which then appears to result from the bifurcation of the musculo-cutaneous. One of these branches perforates the biceps, and passes transversely outwards to reach the elbow joint, to which it is distributed.

The *branches for the brachialis anticus* almost always arise by a large common trunk which appears to result from a further bifurcation of the nerve, already diminished one half, after it has supplied the branches for the biceps. While these last-named branches enter the posterior surface of the corresponding muscle, the branches for the brachialis anticus penetrate that muscle by its anterior surface.

After having given off all these muscular branches, the musculo-cutaneous nerve, reduced to a fourth or a fifth of its original size, is distributed entirely to the skin; it passes vertically downwards in front of the elbow joint, behind the median cephalic vein (*a*, *fig.* 287.), and divides into two terminal branches, of which the *internal* (*h*) runs along the inner, and the *external* along the outer side of the radial vein.

These two branches, during their course along the fore-arm, lie between the fascia of the fore-arm and the superficial fascia; they gradually diminish in size as they give off their filaments to the skin, and terminate in the following manner: —

The *external branch* passes to the dorsal surface of the fore-arm and may be traced as far as the skin which covers the carpus.

The *internal branch* has a more extensive distribution; it anastomoses with a branch of the radial nerve at the lower part of the fore-arm, and gives off a deep or articular branch which divides into several twigs that surround the radial artery. One of these twigs expands into a number of filaments which enter the fore-part of the radio-carpal articulation; the others accompany the radial artery in its oblique course upon the outer side of the carpus, and then spread out to terminate on the back part of the synovial membrane of the wrist-joint. After having given off this very remarkable articular branch (§), the

* [And with the internal cutaneous branch of the musculo-spiral nerve.]

† [The nerve is also called *perforans Casserii*.]

‡ Not unfrequently the nerve does not perforate the coraco-brachialis. [It sometimes has an anastomosis with the median nerve after emerging from the coraco-brachialis.]

§ In one subject, the articular filaments had some gangliform enlargements on their sides

internal terminal division of the musculo-cutaneous nerve passes in front of the tendons of the extensor brevis pollicis and abductor longus pollicis, in front of and more superficially than the corresponding branch of the radial nerve, and then divides into several twigs, which are intended for the skin of the thenar eminence. One of these branches, which runs along the outer side of that eminence, may be traced into the skin upon the first phalanx of the thumb.

Summary. The musculo-cutaneous nerve, then, supplies :—Certain *muscular branches*, which belong exclusively to the coraco-brachialis, the biceps, and the brachialis anticus: the section of this nerve would, therefore, destroy the power of flexing the fore-arm. Certain *cutaneous branches* to the skin on the outer side of the fore-arm and hand; and, lastly, some *articular branches* to the elbow and to the wrist.

The Median Nerve.

The *median nerve* (*c*, *fig.* 286.), one of the terminal branches of the brachial plexus, arises from the plexus by two very distinct roots between the musculo-cutaneous, (*b*) on the outer side, and the ulnar nerve (*d*) on the inner.* The internal root arises from a nervous cord which is common to it, to the ulnar, and to the internal cutaneous (*g*). The external root arises from a cord common to it, and to the musculo-cutaneous. The axillary artery passes between these two roots.

The trunk, resulting from the union of these two roots, is situated on the inner side of the axillary artery; it is at first grooved to receive the inner half of the artery, but it soon forms a rounded cord, proceeds vertically downwards, (*c*, *fig.* 288.) gains the middle and fore part of the elbow joint, dips between the muscles on the anterior region of the fore-arm (*d*), and passes behind the annular ligament to enter the palm of the hand (*r*), where it terminates by dividing into six branches. We shall examine it in the arm, the fore-arm, and the hand.

In the Arm.

The median nerve (*c*), which is straight and vertical, and the satellite nerve of the brachial artery, passes somewhat obliquely downwards, forwards, and outwards, to the middle and fore part of the elbow-joint.

Relations. On the *inner side*, it is sub-aponeurotic, so that when the arm is held away from the side, and the fore-arm is extended upon the arm, it projects below the skin like a tense cord, which is very distinctly seen in emaciated subjects.

On the *outside*, it corresponds at first to the brachialis anticus, and is then received in the sort of groove formed between the inner border of the biceps and the brachialis anticus.

In *front*, it is covered by the inner border of the biceps, excepting in emaciated subjects.

Behind, it is in relation with the ulnar nerve (*f*), and then with the brachialis anticus.

Its *relations with the brachial artery* are of the greatest importance, in reference to the application of a ligature to that vessel. The nerve is at first situated to the outer or radial side of the axillary artery, but soon passes in front of the vessel, and then it crosses over slightly, so that at the bend of the elbow it is situated about two lines to the inner or ulnar side of the artery.

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precisely similar to those which are met with on the cutaneous nerves in the palm of the hand; the articular filaments, moreover, have almost always the greyish aspect of the nerves of organic life.

* These two roots of the median nerve, when united to the musculo-cutaneous and the ulnar, represent very nearly a capital M. Not unfrequently there is a third internal root for the median nerve.

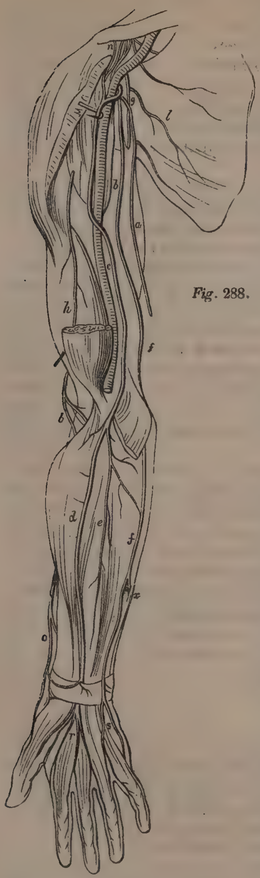

Fig. 288.

This last relation is not constant: I have seen the nerve on the outer side of the artery at the bend of the elbow.

The following are its *relations with the other nerves:* the internal cutaneous nerve runs along its inner side, at first immediately in contact with it, and then separated from it by the fascia of the arm.

The ulnar nerve runs behind it in the upper third of the arm, and is then separated from it, so that the two nerves bound the sides of a triangular interval, the base of which is below and the apex above.

The median nerve does not give any branch in the arm.*

In the Fore-arm.

The median nerve, like the brachial artery, to the inner side of which it is generally situated, passes beneath the tendinous expansion of the biceps, and is separated from the elbow-joint by the brachialis anticus.

It almost always perforates the pronator teres in such a manner as to leave only a very small tongue of fleshy fibres behind it †; it then passes (*d, fig.* 288.) between the flexor sublimis and flexor profundus digitorum, opposite the cellular interval between the latter muscle and the flexor longus pollicis: at the lower part of the fore-arm it runs along the outer border of the flexor sublimis, where it might be easily exposed between the tendon of the palmaris longus on the inside, and of the flexor carpi radialis on the outside. I have seen this nerve perforate the upper part of the flexor sublimis, which formed a sheath for it.

Branches. These are muscular, excepting the palmar cutaneous, which arises at the lower part of the fore-arm: they supply all the muscles of the anterior region of the fore-arm except a part of the flexor profundus, and the whole of the flexor carpi ulnaris, which receive branches from the ulnar nerve. Lastly, with the exception of the palmar cutaneous, the branches arise near the bend of the elbow.

The *branch for the pronator teres* comes off from the anterior part of the median nerve, a little above the elbow-joint, and passes downwards to enter the substance of the muscle. It gives off several *articular filaments*, which dip from before backwards, around the termination of the brachial artery and the commencement of the radial and ulnar arteries, form loops with their concavities turned upwards in the angle of bifurcation of the brachial, and then enter the articulation.

* [Except occasionally an anastomotic branch to the musculo-cutaneous, after the latter has emerged from the coraco-brachialis.]

† In one case, in which the humeral attachments of the pronator teres were as high as those of the supinator longus, the median nerve passed through the highest attachments of the pronator teres, and was situated between the brachialis anticus and that muscle, which also covered it at the bend of the elbow; in this same case, the brachial artery divided into the radial and ulnar at the middle of the arm; and the ulnar artery applied against the nerve had the same relations as the brachial artery in ordinary cases.

The other collateral branches of the median in the fore-arm arise from its posterior aspect: they are the *branch for the superficial layer of muscles*, which arises opposite the elbow-joint and then divides successively into several others, which enter the *pronator teres*, the *flexor carpi radialis*, the *palmaris longus*, and the *flexor sublimis*. The filaments for the flexor sublimis are remarkably slender and are reflected upwards below the epitrochlea: they belong to the upper part only of this muscle, which is also supplied by two or three other branches given off in succession from the median, a little below the bend of the elbow.

The *branch for the deep layer of muscles* is a large trunk which soon divides into several branches, viz. one *external*, for the *flexor longus pollicis*, the upper extremity of which it enters; two *internal*, which enter the *flexor profundus* but only supply its inner half, the other half receiving its nerves from the ulnar *; and a *middle* branch, the *inter-osseous nerve* (*e*), which requires a particular description. It passes vertically downwards, in front of the inter-osseous ligament between the flexor profundus and the flexor longus pollicis, to both of which it gives several filaments; having reached the upper borders of the pronator quadratus, it passes behind that muscle and divides into a great number of filaments, some of which penetrate the muscle from behind, whilst others descend to gain the lower part of the muscle. I have seen the inter-osseous nerve perforate the inter-osseous ligament, run a very short distance upon its posterior surface, then pass through it again, and ramify in the pronator muscle.

The *palmar cutaneous branch* (*i*, *fig.* 287.) comes off from the median nerve opposite the junction of the three upper fourths with the lower fourth of the fore-arm, runs along the median nerve, and divides into two branches which perforate the fascia of the fore-arm immediately above the annular ligament. The *external branch* is the smaller, and crosses obliquely over the tendon of the flexor carpi radialis, and terminates in the skin upon the ball of the thumb †; the *internal branch*, which is larger, descends vertically in front of the annular ligament and beneath the skin, from which it is separated by a layer of adipose tissue, and is lost in the palm of the hand, much sooner than might be expected from its size ‡; it can scarcely be traced as far as the middle of the palm.

In the Hand.

The median nerve, while passing behind the annular ligament of the carpus, becomes considerably wider and flattened; it might even be said to increase gradually in size. Immediately after it has passed below the ligament, still flattened out, it divides (*r*) into two branches, one *internal*, the other *external*, which are themselves subdivided; the internal into two, and the external into four branches, so that in all there are six terminal branches.

The *terminal branches* of the median nerve. Of these one only is muscular, and belongs to the muscles of the ball of the thumb; the other five are intended for the integuments of the fingers, of which they form the palmar collateral nerves.

The *branch for the muscles of the ball of the thumb* is a recurrent nerve; it arises from the front of the median, passes upwards and outwards, forming a horizontal curve with the concavity turned upwards, perforates the superficial layers of the flexor brevis, immediately gives off a descending branch to that muscle, and, continuing to ascend itself, is divided almost equally between the abductor brevis and the opponens pollicis.

* All the deep branches may be traced as far as the periosteum of the bones of the fore-arm. [Some of them have been seen to communicate with filaments of the ulnar nerve.]

† [This branch anastomoses with the terminal cutaneous division of the musculo-spiral or radial nerve.]

‡ This sudden mode of termination is common to all nerves of sensation, which are often lost almost immediately in the skin; the nerves of motion, on the other hand, run a very long course as filaments before they terminate in the muscles.

*The external collateral branch of the thumb.** This nerve passes obliquely downwards and outwards, on the inner side of the tendon of the flexor longus pollicis, crosses the metacarpo-phalangal articulation, to gain the external border of the anterior surface of the thumb, and, running along the outer side of the tendon of the long flexor, arrives at the ungual phalanx. On this phalanx, it divides into two branches, a *dorsal* or *ungual*, properly so called, which turns round the side of the phalanx, anastomoses with the dorsal collateral branches of the radial nerve, and is distributed to the dermis beneath the nail; and a *palmar*, which is lost in the skin covering the pulp of the thumb. Some of these latter filaments turn round the tip of the phalanx and are distributed to the skin beneath the nail. None of the filaments of the external collateral branch anastomose with those of the internal collateral.

The *internal collateral branch for the thumb* is less oblique in its course and larger than the preceding; it runs along the first interosseous space in front of the adductor pollicis, and reaches the inner side of the anterior surface of the thumb, along the tendon of the long flexor, and terminates like the preceding branch. This branch gives off a twig to the adductor pollicis.

The *external collateral branch for the index finger* sometimes arises by a common trunk with the preceding; it runs along the first interosseous space in front of the adductor pollicis, on the outer border of the first lumbricalis muscle, to which it gives a filament, and then divides into two branches, a *dorsal* and a *palmar* : the *dorsal branch*, which is the smaller, passes backwards and downwards, along the outer border of the first phalanx, unites with the dorsal collateral branch derived from the radial nerve, gains the posterior surface of the second phalanx, and terminates upon the third, near the nail. The *palmar branch*, which forms the true continuation of the trunk of the nerve, is arranged like the corresponding nerve of the thumb, and does not anastomose with the internal collateral branch.

The *common trunk of the internal collateral branch of the index finger, and external collateral branch of the middle finger*, passes vertically downwards, in front of the second interosseous space, at the middle of which it divides into two branches, one of which forms the *internal collateral branch of the index finger*, and the other the *external collateral branch of the middle finger*. These collateral nerves, like the preceding, divide into a dorsal and a palmar branch, the latter of which again subdivides into a sub-ungual branch and a branch for the pulp of the finger.

The common trunk of these two collateral nerves, before bifurcating, gives off a twig to the second lumbricalis.

The *common trunk of the internal collateral branch of the middle finger, and external collateral branch of the ring finger*, passes somewhat obliquely inwards, in front of the third interosseous space, and is distributed in the same way as the preceding branches; before bifurcating, it sometimes gives a twig to the third lumbricalis; it receives an anastomotic filament from the ulnar nerve. The bifurcation of this sixth branch takes place a little below the metacarpo-phalangal articulations.

Relations. The following are the relations of the palmar and digital portions of the median nerve :

Behind the anterior annular ligament of the carpus, the median nerve is situated on the outer side of the tendons of the flexor sublimis and in front of those of the flexor profundus : like the tendons among which it is placed, it is at first covered by the synovial membrane in front and behind.

In the *palm of the hand*, the median nerve is covered by the palmar fascia and is situated in front of all the flexor tendons. The superficial palmar arch lies in front of it, and crosses at right angles over its three internal branches.

The *collateral nerves of the fingers* accompany the collateral vessels, and pass with them from the palm of the hand opposite the intervals between the

* I have seen it arise after the third branch, and upon a plane anterior to that branch, the origin of which it then crossed.

metacarpo-phalangal articulations. Like the vessels which run along their outer side, these nerves occupy the borders of the palmar aspect of the fingers, one on each side of the tendinous groove.

Summary. From what has been stated, it follows, then, that the median nerve gives off no branch in the arm*; that in the fore-arm, it gives no nerve to the skin, but supplies all the muscles of the anterior region, excepting the flexor carpi ulnaris and the inner half of the flexor profundus, which we shall see are supplied by the ulnar; and lastly, that, in the hand, it supplies the cutaneous nerves of the palm, the external and internal collateral nerves of the thumb, index finger, and middle fingers, and the external collateral nerve of the ring finger, and also the muscular nerves of the ball of the thumb and the nerves of the two outer lumbricales, and sometimes that of the third lumbricalis.

The Ulnar Nerve.

The *ulnar nerve* (*d*, *fig.* 286.) a little smaller than the preceding, behind which it is situated, arises by a trunk which is common to it, to the internal root of the median nerve (*c*), and to the internal cutaneous nerve (*g*); it passes vertically downwards behind, and at first in contact with the median, but soon leaves that nerve, and runs somewhat backwards (*f*, *fig.* 288.), whilst the median is directed forwards and outwards; it perforates the upper fibres of the internal head of the triceps and enters the sheath of that muscle behind the internal intermuscular septum. It thus gains the groove between the inner condyle of the humerus and the olecranon, passes between the two origins of the flexor carpi ulnaris, and is reflected from behind forwards in this groove, and then upon the inner side of the coronoid process: having thus reached the anterior aspect of the fore-arm, it passes vertically downwards (*f*) between the flexor carpi ulnaris and the flexor profundus, and gains the palm of the hand (*s*), where it divides into its terminal branches. As with the median nerve, we shall examine the ulnar in succession in the arm, the fore-arm, and the hand.

In the Arm.

The most important relation of this nerve (*f*) in the arm is that at its upper part with the median nerve and brachial artery. It runs along the inner side of the artery, whilst the median nerve is situated in front of the vessel, or rather the artery is situated between the median and ulnar nerves, so that it may be exposed immediately below the axilla, by separating these two nerves.

The ulnar nerve gives off no branch in the arm; the error of those who have stated the contrary has arisen from the fact that the branch given from the musculo-spiral nerve to the internal portion of the triceps lies in contact with the ulnar nerve for a great part of its extent, so that it would seem at first sight to come off from it.

The Fore-arm.

The ulnar nerve in the fore-arm (*f*) is at first covered by the fleshy belly of the flexor carpi ulnaris, which separates it from the skin, it becomes sub-aponeurotic below, where the fleshy fibres of that muscle cease, and is found between the tendon of the flexor carpi ulnaris on its inner side, and those of the flexor sublimis on its outer side.

Its relation with the ulnar artery is remarkable. This vessel describes a curve so as to reach the outer or radial side of the nerve; but the nerve and artery are in contact in the lower third only of the fore-arm.

The *branches* of this nerve in the fore-arm are somewhat numerous. Between the internal condyle and the olecranon, the ulnar nerve gives several very delicate *articular filaments* which pass into the elbow joint; it also gives off branches for the *flexor carpi ulnaris*, one of which is very large and may be traced as far as the lower part of the fleshy belly of the muscle.

After its reflection, the ulnar nerve gives a branch to the *flexor profundus*

* See note, p. 1053.

digitorum, which subdivides and enters the substance of that muscle. Its divisions run upon the anterior surface of the muscle before penetrating it. This branch is intended for the two inner portions of the flexor profundus, the two outer portions receiving their filaments from the median nerve.*

At the middle of the fore-arm, a small, long, and slender branch is given off from the anterior part of the ulnar nerve, and divides into two filaments, one of which follows the ulnar artery (*filament of the ulnar artery*), whilst the other perforates the fascia of the fore-arm and anastomoses with the internal cutaneous nerve (*anastomotic filament*).

The *internal dorsal nerve of the hand* (x) is the largest of the branches of the ulnar nerve; so that it might be regarded as a terminal branch of that nerve; it is exclusively intended for the skin of the dorsal region of the hand. It comes off opposite the junction of the two upper thirds with the lower third of the fore-arm, passes obliquely downwards, backwards, and inwards, between the ulna, over which it crosses, and the flexor carpi ulnaris, and emerges (x, *fig.* 289.) from below the tendon of that muscle, a very short distance above the lower end of the ulna. It then descends vertically between the skin and that part of the bone, runs along the inner side of the carpus and divides into two *dorsal branches*, an *internal*, and an *external.*

The *internal dorsal branch* is the smaller, it runs along the ulnar border of the fifth metacarpal bone, and along the internal or ulnar side of the dorsal region of the little finger, of which it forms the *internal collateral dorsal nerve.*

The *external dorsal branch* is much larger; it first gives off a small *anastomotic twig* which crosses obliquely over the metacarpal bone and anastomoses with a correspondingly oblique branch from the radial nerve opposite the lower part of the second interosseous space. It then descends vertically along the fourth interosseous space and divides into two secondary branches, which again subdivide to form the *dorsal collateral* nerves in the following manner: one forms the *external collateral nerve of the little finger*, and the *internal collateral nerve of the ring finger;* and the other the *external collateral nerve of the ring finger*, and the *internal collateral nerve of the middle finger.*†

In the Hand.

The ulnar nerve enters the palm of the hand (s, *fig.* 288.), not by passing behind the anterior annular ligament but in a special sheath, which is common to it and to the ulnar artery, is situated on the inner side of the annular ligament, and has the pisiform bone to its inner side, and the unciform bone to its outer side. This sheath is completed behind by the ligament which extends from the pisiform to the unciform bone, and in front by a sort of annular ligament. The nerve is covered by a synovial membrane during its passage through this sheath.

As soon as it leaves this sheath, the ulnar nerve divides into two *terminal branches*, the one *superficial*, and the other *deep.*

The *superficial terminal branch* or *trunk of the palmar collateral nerves of the fingers* immediately gives off a branch which passes beneath the flexor brevis digiti minimi, penetrates the deep surface of that muscle, and immediately divides into two other branches, *an internal* and an *external.* The *internal* is the smaller branch; it crosses over the muscles of the ball of the little finger, beneath the palmaris brevis when it exists, gains the inner side of the anterior surface of the little finger, and forms its *internal palmar collateral nerve.*‡ The *external* is larger; it sends a communicating twig to the median nerve, and bifurcates to form the *external palmar collateral nerve of the little finger*, and the *internal palmar collateral nerve of the ring finger.*

The *deep terminal* or *muscular branch* is somewhat larger than the superficial branch. Immediately after its origin, it is reflected outwards below the

* [The ulnar may communicate in this position with filaments of the anterior interosseous.]

† [This latter branch often anastomoses with the dorsal cutaneous branch of the radial nerve.]

‡ I have observed that it supplies the palmaris brevis, when that muscle exists.

unciform bone, perforates the flexor brevis digiti minimi, and passes deeply into the palm of the hand, so that it cannot be exposed without dividing all the tendons of the palmar region.

This branch describes a transverse curve or arch with the concavity directed upwards, in front of the metacarpal bones, corresponding to and situated within the curve described by the deep palmar arterial arch, which crosses it at an acute angle.

No branch arises from the concavity of this nerve, but from its convexity a great number are given off in the following order :—

During the passage of the nerve between the pisiform and unciform bones, three branches for *the three muscles of the hypothenar eminence.*

Two very remarkable descending filaments which supply the *palmar interossei* of the *third* and *fourth* spaces, and end in the *third* and *fourth lumbricales.* The first and second lumbricales, and frequently the third also, are supplied by the median nerve.

Three *perforating branches* pass backwards between the upper ends of the metacarpal bones, give some branches to the palmar interossei, proceed along the cellular interval between the palmar and dorsal interossei, supply the last-mentioned muscles, and terminate by anastomosing with the dorsal collateral branches of the ulnar and radial nerves.

We may regard as terminal divisions of the deep branch; two branches, which are given to the two portions of the adductor pollicis,* and a branch for the *first dorsal interrosseous muscle*, from which a filament is given off that enters the adductor pollicis near its lower border.

Summary. From what has been stated, it appears that the ulnar nerve gives off no branch in the arm: that in the fore-arm it supplies some articular branches to the elbow-joint, certain muscular branches for the flexor carpi ulnaris and the inner half of the flexor profundus, and a cutaneous filament which anastomoses with the internal cutaneous nerve: that it gives off to the hand a *dorsal cutaneous branch*, from which the dorsal collateral nerves of the little and ring fingers, and the internal dorsal collateral of the middle finger, proceed; a *palmar cutaneous division* which supplies the palmar collateral nerves of the little finger, and the internal palmar collateral nerve of the ring finger; and a *muscular division*, which is distributed to the three muscles of the hypothenar eminence, to all the interossei, among which we may include the adductor pollicis, † and to the two internal lumbricales.

Musculo-spiral Nerve.

The *musculo-spiral* or *radial nerve*, which is the largest of the terminal divisions of the brachial plexus, is intended for the triceps extensor cubiti, for the muscles of the posterior and external region of the fore-arm, and for the skin of the arm, the fore-arm, and dorsal region of the hand.

It arises (*f*, *fig.* 286.) from all the five nerves of which the brachial plexus is composed, by a trunk which is common to it and to the circumflex nerve, and it issues from the plexus behind the ulnar nerve, to which it is closely applied. Immediately after its origin, it passes downwards, backwards, and outwards (*b*, *fig.* 288.), in front of the conjoined tendons of the latissimus dorsi and teres major, to gain the groove of torsion or spiral groove of the humerus, into which it enters, passing between the long head of the triceps and the bone, then between the external head and the bone; it traverses the whole extent of

* The reader must here be reminded, that I have regarded all that portion of the flexor brevis pollicis (of authors) which is situated to the inner side of the tendon of the flexor longus pollicis, or in other words, all that portion which is attached to the internal sesamoid bone, as belonging to the adductor pollicis. (See MYOLOGY, vol. i. p. 340.) The distribution of the nerves favours this view; for the flexor brevis is supplied by the median nerve, while the two portions of the adductor receive their nerves from the ulnar. [This general statement is not quite correct; the outer portion of the adductor (the inner head of the flexor brevis of authors generally) also receives a small branch from the median nerve (see p. 1054.; also Swan and Ellis).]

† It is perfectly rational to consider the adductor pollicis as the first palmar interosseous muscle, which, for the sake of increased power of adduction, is attached to the third metacarpal bone.

this groove, and is in relation with the profunda humeri artery and vein. Leaving this groove, opposite the junction of the two upper thirds with the lower third of the humerus, it lies on the external and anterior aspect of the arm, descends vertically between the supinator longus and brachialis anticus, and next between the brachialis anticus and extensor carpi radialis longior, crosses the elbow joint (at *b*) passing in front of the outer condyle of the humerus and the upper extremity of the radius, and then divides into two terminal branches.

Collateral Branches of the Musculo-spiral Nerve.

During its winding and spiral course along the arm, this nerve gives off a great number of collateral branches in the following order:—

Branches given off by the musculo-spiral nerve before it enters the spiral groove. The first is the *internal cutaneous branch* (*f′*, *fig.* 287.) of the musculo-spiral, which is sub-aponeurotic at its commencement, but perforates the fascia, becomes applied to the skin, and divides into two filaments which pass obliquely backwards and may be traced as far as the olecranon. *

There are several considerable *branches to the long head of the triceps;* the highest of which is recurrent and may be traced as far as the scapular attachments of the muscle. A very large descending branch may be traced to the olecranon.

There is *a branch for the internal head of the triceps*, one division of which is rather large, and runs along the inner border of the humerus in front of the muscle, which it does not enter until it approaches the elbow.

Branches given off by the musculo-spiral after leaving the spiral groove. These are, the *external cutaneous branch of the musculo-spiral*, a very large branch which perforates the muscular fibres of the triceps and the brachial aponeurosis, then lies in immediate contact with the skin of the external region of the arm, passes obliquely backwards and divides into a great number of filaments which supply the skin of the posterior region of the fore-arm and may be traced down to the carpus.

The *branch for the external head of the triceps and for the anconeus*, which is remarkable for its length, descends vertically between the external and long heads of the triceps, supplies the former of these, enters the anconeus and may be traced as far as the lower part of that muscle.

All these branches are remarkable for being given off at nearly the same height; that is to say, near the shoulder-joint, and for accompanying the trunk of the musculo-spiral nerve.

Branches given off by the musculo-spiral nerve in the fore-arm. These are, the branches for the *supinator longus*, and those for the *extensor carpi radialis longior*, which enter the inner surface of the upper part of those muscles.

Terminal Branches of the Musculo-spiral Nerve.

Reduced to one half, or less, of its original size, by the successive emission of the preceding branches, the musculo-spiral or radial nerve divides in front of the elbow (*b*, *fig.* 288.) into two unequal branches, the one *deep* or *muscular*, the other *superficial* or *digital.*

The *deep* or *muscular division* of the musculo-spiral nerve, or the *posterior interosseous* is larger than the superficial division; it immediately gives off a branch which passes vertically in front of the extensor carpi radialis brevior, and soon dips into that muscle; the nerve then becomes flattened, perforates the supinator brevis, and pursues a very oblique and spiral course around the radius and within that muscle, to which it gives branches (*branches for the supinator brevis*): it then emerges from the posterior aspect of this muscle, and immediately divides into a great number of diverging branches, some of which are intended for the superficial and the others for the deep layer of muscles on the posterior region of the fore-arm.

The branches given to the superficial layer are: those *for the extensor com-*

* [Anastomosing with the accessory of the internal cutaneous.]

munis digitorum, which are very numerous and diverging, the superior being also recurrent; the *branch for the extensor proprius digiti minimi*; and *the branch for the extensor carpi ulnaris*: all these branches arise by a common trunk and enter the deep surface of the muscles.

The *branches for the deep layer* also arise by a common trunk (*i*, *fig.* 289.), which may be regarded as the continuation of the muscular division of the musculo-spiral considerably diminished in size. This common trunk passes vertically downwards between the superficial and deep layers of muscles, gives off a branch, which enters the superficial aspect of the *extensor longus pollicis*, then passes between the adductor longus and extensor brevis pollicis on the one hand, and the extensor longus pollicis on the other, runs in contact with the interosseous ligament, and gives off a first branch to the *extensor longus pollicis*, a second which enters the deep surface of the same muscle, and a small branch which enters the outer border of the *extensor proprius indicis.*

Fig. 289.

Reduced at length to a very small branch, the muscular division of the musculo-spiral nerve enters the groove (at *s*) for the tendons of the extensor communis digitorum, lying beneath them, in contact with the periosteum; it runs over the carpus, and expands into a number of *articular filaments*, which enter the radio-carpal, carpal, and carpo-metacarpal articulations; in this latter portion of its course, the nerve is of a greyish colour, swollen, and as it were knotted, a condition which is observed in all articular nerves.

The *superficial, cutaneous or digital division of the musculo-spiral nerve*, or the *radial nerve* properly so called, forms the *external dorsal nerve of the hand*, and is about half the size of the muscular division. It passes vertically downwards, between the supinator longus and the extensor carpi radialis longior, along the outer side of the radial artery: having reached the middle of the fore-arm, it escapes from beneath the tendon of the supinator longus, and runs along the outer border of that tendon.

Situated at first beneath the fascia, it soon perforates it, becomes subcutaneous, runs vertically downwards, and, about an inch and a half above the styloid process of the radius, divides into an *external* and an *internal* branch.

The *external branch* (*o*, *figs.* 288, 289.), which is the smaller, runs along the outer side of the styloid process of the radius, and then along the outer border of the carpus *, of the first metacarpal bone, and of the first and second phalanges of the thumb, and terminates in the skin beneath the nail; it is the *external dorsal collateral branch of the thumb.*

The *internal branch* (*e*, *fig.* 289.), which is much larger, passes obliquely behind the radius, crosses the tendons of the adductor longus and extensor brevis pollicis, and divides into three secondary branches, namely, counting from without inwards, the *internal dorsal collateral nerve of the thumb*, and *the external and internal dorsal collateral nerves of the index* finger.†

Summary. The musculo-spiral nerve gives off: *in the arm*, *two cutaneous branches*, one internal, the other external, the latter of which is much the larger, and may be traced as far as the carpus; and also *muscular branches* to the three portions of the triceps and to the anconeus: to the *fore-arm*, it supplies *muscular branches* to all the muscles of the deep and superficial layers of the posterior and external regions; and to *the hand*, certain cutaneous branches, namely, the dorsal collateral nerves of the thumb and index finger.

* [Where it sends an anastomotic filament to the palmar cutaneous branch of the median.]

† [It also supplies the external dorsal collateral of the middle finger, and often unites with the ulnar cutaneous to form the dorsal collaterals for the contiguous sides of the middle and ring fingers.]

General Summary of the Distribution of the Nerves of the Brachial Plexus.

The preceding description shows that the brachial plexus supplies the skin, the muscles, and the articulations of the upper extremity, including the shoulder. We shall briefly recapitulate, first the muscular and then the cutaneous branches.

The muscular branches. By its collateral branches, the brachial plexus supplies the scaleni and all the muscles which move the shoulder, excepting the trapezius, which receives its nerves from the brachial plexus and from the spinal accessory nerve of Willis; by its *terminal branches* it supplies all the muscles of the arm, the fore-arm, and the hand.

Each of the *muscles which move the shoulder* receives a special nerve: thus, besides the nervous filaments for the scaleni, there is the nerve for the subclavius; the nerve for the levator anguli scapulæ; the nerves for the rhomboideus; the nerve for the serratus magnus, which is better known as the external thoracic nerve; the nerve for the latissimus dorsi, which is generally described as a branch of the subscapular; and the nerves for the pectoralis major and minor.

The *muscles which move the arm* upon the shoulder also receive their nerves from the brachial plexus; sometimes there is a separate nerve for each muscle, sometimes the same nerve supplies two muscles. The nerve for the deltoid, or the circumflex nerve, also supplies the teres minor. The supra-spinatus and infra-spinatus receive their filaments from the same branch, viz. the suprascapular nerve. The teres major receives a branch from the subscapular nerve.*

Of the *muscles which move the fore-arm upon the arm.* Those of the anterior region, or the flexors, viz. the biceps, coraco-brachialis, and brachialis anticus, receive their filaments from the musculo-cutaneous nerve; the muscle of the posterior region, the triceps, is supplied entirely by the musculo-spiral nerve. The ulnar nerve gives no branch in the arm.

The *muscles which move the radius upon the ulna*, and those *which move the hand and the fingers*, are thus supplied. The interosseous division of the musculo-spiral nerve supplies the muscles of the posterior region of the fore-arm, viz. in the *superficial layer*, the common extensor, the extensor proprius digiti minimi, and the extensor carpi ulnaris; in the *deep layer*, the supinator brevis, the adductor longus, extensor brevis and extensor longus pollicis, and the extensor proprius indicis.

The *muscles of the external region of the fore-arm*, namely, the two supinators, and the two radial extensors of the carpus, also receive their branches from the musculo-spiral nerve.

The *muscles of the anterior region of the fore-arm* receive their filaments from the median nerve, excepting the flexor carpi ulnaris and the internal half of the flexor profundus, which are supplied by the ulnar nerve. The flexor profundus then, by a peculiarity which not unfrequently occurs in regard to compound muscles, receives its nerves from two different sources.

The *intrinsic muscles of the hand* are supplied in the following manner: — Those of the ball of the thumb by the median nerve; those of the ball of the little finger by the ulnar nerve; the two external lumbricales by the median nerve; the two internal lumbricales by the ulnar nerve; all the interossei, including the adductor pollicis, by the ulnar nerve.

The cutaneous branches †. The skin which covers the shoulder on the outer side receives its nerves from the cervical plexus.

* The teres minor and the infra-spinatus are, therefore, supplied by two different branches, which would induce us to describe these two muscles separately, did we not see that compound, and sometimes even simple, muscles receive two or more distinct nerves.

† A beautiful preparation of the cutaneous nerves of the upper extremity may be made by removing the skin, either by turning it inside out, in the same way as an eel is skinned, or by making a longitudinal incision along the outer side of the limb. In both cases the fascia should be removed with the skin. In the first method, by which a very fine preparation may be made,

The skin of the external surface of the arm receives its nerves from the cutaneous branches of the circumflex nerve, and from the external cutaneous branch of the musculo-spiral. The skin of the internal and anterior regions of the arm receives its nerves from the internal cutaneous branch of the musculo-spiral, from the accessory nerve of the internal cutaneous, which anastomoses with the second intercostal, from a small branch of the internal cutaneous, and from the humeral branch of the third intercostal.

The skin of the fore-arm receives its filaments from the internal cutaneous, which anastomoses with the cutaneous filaments of the musculo-spiral, ulnar, and musculo-cutaneous nerves.

The skin of the dorsal region of the hand and of the fingers receives its filaments from the dorsal branches of the radial nerve, in the two external thirds of that region, and from the dorsal branch of the ulnar nerve in the internal third.

The skin of the *palmar region* of the hand and fingers receives its filaments from the median nerve in the two external thirds, and from the ulnar in the internal third, or to speak more precisely, the median nerve supplies the external and internal collateral branches of the thumb, the index, and the middle fingers, and the external collateral nerve of the ring finger; the ulnar nerve supplies the external and internal collateral nerves of the little finger, and the internal collateral branch of the ring finger.

Some of the terminal branches of the median nerve, and the terminal divisions of the internal cutaneous and musculo-cutaneous, are lost in the skin of the upper part of the palm of the hand.

The palmar collateral nerves of the fingers offer the following peculiarities: the branches which they give to the skin are placed either opposite to each other, or alternately; each of these branches terminates separately in a pencil of filaments; the twigs from the internal branches do not anastomose with those from the external; lastly, the terminal extremities of the external and internal collateral branches do not anastomose with each other in the pulp of the finger, but expand separately, and are distributed to the skin of the pulp and to the skin under the nail.

The branches which supply the palmar aspect of the fingers present a very remarkable condition*, consisting in the presence of small, greyish, gangliform bodies, always of a crescentic form. These bodies are very numerous; they are sometimes separate, and sometimes arranged in groups; they do not essentially belong to the nerves, but are applied to them, and may be separated from them by slight force. They are therefore not ganglia.

If we consider that these gangliform bodies occupy the palmar region only, and are never found in the dorsal region, that they exist in the sole of the foot as well as in the palm of the hand, that they have been found upon the nerves which surround the articulations, and consequently upon nerves which are subjected to constant pressure, that I have even found them upon an intercostal nerve which was reflected over the side of the sternum, and lastly, that they do not exist in the infant at birth, and are more numerous in proportion as the palm of the hand is more callous, we shall be warranted in concluding that they are the result of external pressure.

THE ANTERIOR BRANCHES OF THE DORSAL NERVES, OR THE INTERCOSTAL NERVES.

Dissection.—Enumeration.—Common Characters.—Characters proper to each.

Dissection. Search carefully for the cutaneous branches, some of which are to be found opposite the sides of the sternum, and others about the middle of the intercostal spaces. Saw through the sternum in the median line, and open

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the everted skin represents a sort of glove, the inner surface of which is formed by the epidermis, and the outer by the deep surface of the skin.

* This was pointed out, in one of the last concours of the assistants (aides) of the Faculty, by MM. Andral, Camus, and Lacroix, who had to dissect the cutaneous nerves of the hand.

the abdomen through the linea alba. Sacrifice one half of the thorax, or rather break the ribs through the middle, so as to trace the nerves from within outwards.

The *anterior branches of the dorsal nerves*, twelve in number, are intended for the parietes of the thorax and abdomen.*

These branches offer at once a great uniformity, and a great simplicity in their distribution. I shall first explain their common characters, and shall then notice the peculiarities presented by each.

Common Characters.

The *anterior branches of the dorsal nerves* or the *intercostal nerves*, separated from the posterior branches by the superior costo-transverse ligament, appear like flattened cords, which pass to the middle of the corresponding intercostal space (see *fig*. 268.); there they are situated between the pleura and the aponeurosis which is continuous with the internal intercostal muscle. After proceeding for a certain distance, they pass between the external and internal intercostal muscles, and approach the groove of the rib above, but they are not lodged in it, for they always lie below the intercostal vessels.

At about the same situation in each space, that is to say, about half way between the vertebral column and the sternum, the intercostal nerves divide into two branches, the one *intercostal*, and the other *perforating* or *cutaneous*.

The *intercostal branch* is the continuation of the trunk of the nerve, and is distinguished from it only by its smaller size. It runs along the lower border of the rib above, and then that of the corresponding costal cartilage; it is sometimes situated on the internal surface of the cartilage, and having reached the forepart of the intercostal space, it perforates this space from behind forwards, runs along the sternum, is inclined somewhat inwards over that bone, and is then reflected outwards, between the pectoralis major and the skin, to which latter it is distributed. These small filaments may be called the *anterior perforating filaments.* During its course, the intercostal nerve and its continuation give off a great number of nervous filaments. Not unfrequently the intercostal nerve gives off, in the back part of the space, a small branch, which reaches the upper border of the rib below. When this branch does not exist, its place is supplied by several twigs which have a similar distribution, some of which even pass to the intercostal space below, crossing obliquely over the internal surface of the rib. In like manner, we sometimes find some small twigs proceeding from the upper side of the nerve over the internal surface of the rib above, and reaching the next intercostal space. Lastly, from the lower side of the intercostal nerve and its continuation a series of twigs are given off, which divide into filaments that curve towards each other so as to form arches or loops, from which the terminal filaments proceed. In no part of the body are there found longer or more delicate nervous filaments; some of them run through half the length of an intercostal space without diminishing in size, and several evidently belong to the periosteum.

The *perforating* or *cutaneous branches* are often larger than the intercostal branches; they pass very obliquely through the external intercostal muscles, and after running for a certain distance between those muscles and the serratus magnus, each of them divides into two smaller branches, the one *anterior*, and the other *posterior* or *reflected:* the *anterior branches* run horizontally forwards, become subcutaneous by escaping between the digitations of the serratus magnus in the eight superior intercostal spaces, and between the digitations of the obliquus externus abdominis in the four lower spaces, and then, becoming applied to the skin, spread into a number of filaments, which almost always anastomose with the adjacent filaments of the nerves above and below.

The *posterior* or *reflected branches* immediately perforate the serratus magnus and the obliquus externus abdominis, are reflected upon themselves, pass back-

* Haller only admits eleven dorsal nerves, because he considers, and not without reason, the twelfth as a lumbar nerve.

wards between the latissimus dorsi and the skin, and after running horizontally for a distance of one or two inches, are again reflected forwards, and are then lost in the skin.

Proper Characters of each of the Anterior Branches of the Dorsal Nerves.

The first dorsal nerve. This nerve belongs to the brachial plexus, into which it enters immediately after its escape from the intervertebral foramen, crossing over the neck of the first rib at an acute angle. From its size, it resembles the lower cervical nerves, and differs widely from the remaining dorsal nerves. It becomes intercostal only by giving off a small intercostal twig at its exit from the intervertebral foramen. This *intercostal branch* is applied to the under surface of the first rib, which it crosses obliquely from behind forwards, so that it does not reach the first intercostal space until opposite the junction of the rib with its cartilage; it gains the middle of this space near the sternum, at which point it passes forwards through the space, like the other intercostal nerves, and ramifies in the muscles and the skin.

The second dorsal nerve. This nerve crosses obliquely over the second rib on the outer side of its neck, to reach the first intercostal space, and then recrosses the same rib, about its middle, to gain the second intercostal space, where it divides into two branches — the *intercostal*, which follows the lower border of the second rib and presents nothing remarkable, and the *perforating* or *cutaneous* branch, which requires a special description.

The *perforating or cutaneous branch*, which is destined exclusively for the skin of the arm, is much larger than the other branches of the same kind. It emerges from the thorax at the middle of the second intercostal space, immediately below the second rib, passes directly through that space, is reflected at right angles over an aponeurotic arch, runs outwards, and immediately subdivides into two branches of equal size, the one *external*, and the other *internal*.

The *external* or *intercosto-humeral branch* (to the left of *d*, *fig.* 287.) traverses the axilla, receives an anastomotic twig from the accessory nerve (*c*) of the internal cutaneous of the arm, reaches and crosses over the outer border of the latissimus dorsi, and divides into two cutaneous filaments, one of which is distributed to the skin of the posterior region of the arm, whilst the other lies in contact with the skin of the internal region of the arm, runs parallel to the accessory nerve of the internal cutaneous, and may be traced as low down as the elbow.

The *internal branch* crosses the outer border of the latissimus dorsi, lower down than the preceding branch, becomes applied to the skin, and divides into internal and posterior filaments which are lost in the skin of the arm.

The perforating branch, therefore, of the second dorsal nerve completes the system of cutaneous nerves of the arm.

The *third dorsal nerve* is precisely similar to the others, excepting in its *perforating, cutaneous*, or *intercosto-humeral branch*, which is distributed to the integuments both of the thorax and arm. It is much smaller than the preceding; it emerges (*d*, *fig.* 287.) from between the digitations of the serratus magnus, is reflected backwards upon itself, gives a small branch to the mamma, crosses the outer border of the latissimus dorsi, below the perforating branch of the preceding nerve, and having reached the upper part of the shoulder, is reflected upon itself, describing a curve with the concavity turned upwards, and terminates in the skin of the inner and upper part of the arm.

The *fourth, fifth, sixth*, and *seventh dorsal nerves* agree exactly with the general description. The intercostal muscles, the triangularis sterni, the serratus magnus, the obliquus externus abdominis, the upper part of the recti abdominis, and the integuments of the thorax, are supplied with nerves from these branches, in the order and manner already pointed out. I would direct attention to the considerable number of filaments distributed to the skin of the

mamma in the female. The perforating branches of the fourth and fifth dorsal nerves each give a branch to the mamma, and a posterior branch, which crosses the latissimus dorsi, and is distributed to the skin over the scapula; the skin of the mamma receives nerves from the third, fourth, and fifth dorsal nerves.

The *eighth*, *ninth*, *tenth*, and *eleventh dorsal nerves* belong to the intercostal spaces formed by the false ribs: they leave those spaces at the point where the costal cartilages change their direction to bend upwards; they perforate the costal attachments of the diaphragm, without giving that muscle any filaments, continue their oblique course in the substance of the parietes of the abdomen, for which they are destined, and are distributed to these parts, in the same way as the nerves in the intercostal spaces, with some slight modifications. Thus, the *perforating branches* perforate the external intercostals and the obliquus externus abdominis in the same line as the perforating branches of the preceding nerves; the *intercostal branches*, properly so called, having thus become *abdominal*, run between the external and internal oblique muscles, just as, in the upper spaces, they ran between the external and internal intercostals. Having reached the rectus abdominis, they give off a *cutaneous* or *perforating branch*, and then enter the sheath of that muscle, through certain openings at its outer border, and proceed between the muscle and the posterior layer of the sheath: at the junction of the two external thirds with the internal third of the rectus, these branches pass through it very obliquely towards the middle line, and divide into *muscular filaments*, which are lost in the muscle, and the lowest of which pass vertically downwards, and *cutaneous filaments*, which perforate the anterior layer of the sheath of the rectus, on each side of the linea alba, but not always at the same distance from it, and are reflected horizontally outwards in the subcutaneous cellular tissue lying immediately in contact with the skin.

The *twelfth dorsal nerve* (*d*, *fig.* 290.) might, according to the opinion of Haller, be regarded as the first lumbar nerve. It is larger than the other dorsal nerves; it emerges from the vertebral canal between the last rib and the first lumbar vertebra, passes in front of the costal attachments of the quadratus lumborum, runs along the lower border of the twelfth rib, proceeds very obliquely downwards like that rib, perforates the aponeurosis of the transversalis muscle, and, like the preceding nerves, divides almost immediately into two branches. The *abdominal branch*, which corresponds to the intercostal branch of the other nerves, passes horizontally forwards between the transversalis and obliquus internus supplying those muscles, almost always gives off below an anastomotic branch to the abdominal or ilio-inguinal branch of the lumbar plexus, and then penetrates the sheath of the rectus, where it is arranged like the preceding nerves.

The *perforating* or *cutaneous branch* is remarkable for being larger than the abdominal branch, and for its distribution; it perforates very obliquely, and at the same time gives branches to the external and internal oblique muscles, becomes subcutaneous, passes vertically downwards, crosses at right angles over the crest of the ilium, and divides into *anterior*, *posterior*, and *middle branches*, which are distributed to the skin of the gluteal region.

Not unfrequently this gluteal cutaneous branch is given off by the first lumbar nerve, and then the cutaneous branch of the twelfth dorsal nerve is arranged like those of the preceding nerves, and ramifies in the skin between the last rib and the crest of the ilium. There is a mutual relationship between the twelfth dorsal and the first lumbar nerves, so that they are often inversely developed; they always communicate with each other by a branch called the *dorsi-lumbar*, but the mode and place of communication are subject to many varieties: thus it is sometimes effected by a winding branch which runs along the outer border of the quadratus lumborum, at other times it takes place in the substance of the abdominal muscles.*

* In a subject which had a thirteenth or lumbar rib, there was a thirteenth dorsal nerve, of large size, which crossed the supernumerary rib, and which corresponded in its distribution

Summary of the Dorsal or Intercostal Nerves.

These nerves are distributed to the parietes both of the thorax and the abdomen, which in all respects may be regarded as constituting a single cavity, the thoracico-abdominal. The muscular and cutaneous thoracic branches from the brachial plexus, some small branches derived from the lumbar plexus, and the posterior spinal branches of the dorsal nerves, complete the nervous system of the thoracic and abdominal parietes.

The dorsal nerves are divided into *muscular nerves*, for the muscles of the thoracico-abdominal parietes and for the muscles which lie upon them, and into *cutaneous* nerves. To obtain a good idea of the latter they should all be displayed in the same preparation. Several rows of parallel cutaneous filaments will then be seen, in the following order, proceeding from before backwards.

The anterior perforating or cutaneous nerves, which are extremely small, emerge at the sides of the sternum and of the linea alba, and are reflected forwards.

The *perforating* or *cutaneous nerves*, which might be called *middle*, divide into one set of *branches* which run parallel to each other forwards towards the sternum, and another set, also parallel, which run backwards towards the vertebral column.

We have elsewhere stated that other *posterior cutaneous branches* are given off from the posterior branches of the dorsal nerves. They are parallel and run outwards, and may be traced as far as on a level with the axilla.

THE ANTERIOR BRANCHES OF THE LUMBAR NERVES.

Enumeration. — The Lumbar Plexus — Collateral branches, abdominal and inguinal. — Terminal branches — the obturator nerve — the crural nerve and its branches, viz. the musculo-cutaneous — the accessory of the internal saphenous — the branch to the sheath of the vessels — the muscular branches — the internal saphenous.

Dissection. In order to see these nerves at their exit from the intervertebral foramina, and also to obtain a view of the lumbar plexus, it is necessary carefully to divide the psoas muscle, in which they are situated; the branches which emerge from the plexus must be dissected with the greatest care as they are passing under the femoral arch and then to their final distribution.

The *anterior branches of the lumbar nerves* (21 to 25, *fig.* 268.) are five in number, and are distinguished as the first, second, third, fourth, and fifth: they gradually increase in size from the first to the fifth, and form a continuation of the series of anterior branches of the dorsal nerves: after having given off one or two branches to the lumbar ganglia (*u*) of the sympathetic, and some branches to the psoas muscle, they end by anastomosing so as to form the lumbar plexus (*l*).

The *anterior branch of the first lumbar nerve* (1 *l*, *fig.* 290.) is the smallest of all, and is almost equal in size to the anterior branch of the twelfth dorsal nerve; immediately after emerging from the intervertebral foramen it divides into three unequal branches; two of these (*a* and above *b*) are external and oblique, and constitute the *abdominal branches* (*ilio-scrotal nerves* of some authors); the third is internal, vertical, and often very small; it is the *anastomotic branch* which joins the second nerve.

The *anterior branch of the second lumbar nerve* is at least twice as large as

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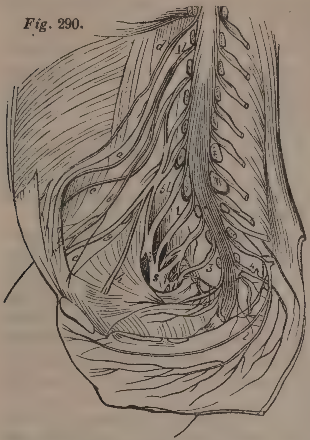
with both the twelfth dorsal and the first lumbar nerves; it only communicated with the first lumbar nerve by a very small filament; it gave off a deep perforating or cutaneous branch to the gluteal region, and also an ilio-scrotal branch. In this subject there were only four lumbar nerves.

the preceding ; it passes almost vertically downwards and gives off an anterior branch, the *internal inguinal* (*génito-crural* of Bichat, *b*), and an external branch, the *external inguinal* (*inguino-cutaneous* of Chaussier, *c*). It is scarcely diminished in size by giving off these nerves, but becomes flattened, plexiform, and ribbon-shaped, furnishes some large branches to the psoas, and anastomoses with the third nerve.

Fig. 290.



The *anterior branch of the third lumbar nerve* is twice as large as the preceding, passes obliquely downwards and outwards, and is joined by the branch from the second nerve which greatly increases its size. The large trunk thus formed, after a short course, divides into two unequal branches, which diverge at a very acute angle, and anastomose with two branches derived from the fourth nerve, to constitute the *crural* (*g*) and the *obturator* (*h*) *nerves.*

The *anterior branch of the fourth lumbar nerve* is a little larger than the third; it divides after a short course into three branches—an external, which unites with the external bifurcation of the third to form the *crural nerve ;* a middle, which unites with the internal bifurcation of the same nerve to form the *obturator nerve ;* and an internal, vertical, *anastomotic* branch, which joins the fifth nerve.

The *anterior branch of the fifth lumbar nerve* (5 *l*) is somewhat larger than the fourth ; it receives the internal branch of that nerve, and with it forms a large trunk, which enters the sacral plexus, and was named by Bichat the *lumbo-sacral nerve* (*i*).

The Lumbar Plexus.

The *lumbar plexus* (*fig.* 290.) (lumbo-abdominal, *Bichat*) is a rather complicated interlacement, formed by the anastomoses of the anterior branches of the lumbar nerves. It is narrow above, where it consists of the sometimes slender communicating cord between the first and second lumbar nerves, and it becomes wider towards its lower part, so as to have a triangular form ; it is situated upon the sides of the lumbar vertebræ between the transverse processes and the fasciculi of the psoas muscle.

The branches which emanate from the lumbar plexus are divided into *terminal branches*, namely the *crural* (*g*), *obturator* (*h*), and *lumbo-sacral nerves* (*i*) ; and *collateral branches*, improperly named *musculo-cutaneous ;* these are four in number, they run between the psoas and iliacus and the peritoneum, and reach the femoral arch. I shall divide these collateral branches into two sets ; an *abdominal* set, subdivided into the *great* (*a*) and *small* (above *b*), and an *inguinal* set, subdivided into the *internal* (*b*) and *external* (*c*).*

Of these collateral branches, the abdominal only run in the subperitoneal adipose tissue, the inguinal branches being covered by a layer of fascia, which keeps them in contact with the psoas-iliac muscle.

* A change in the nomenclature of the collateral branches of the lumbar plexus appeared to me to be necessary. Bichat, who first distinguished them by special names, divides them into external or musculo-cutaneous branches, and an internal or genito-crural branch. Of the three external branches, Chaussier named the external the *ilio-scrotal*, and the internal the *inguino-cutaneous ;* the intermediate one, to which he gave no particular name, retaining its old appellation of the *middle branch*.

Collateral Branches of the Lumbar Plexus.

Abdominal Branches.

The *abdominal branches* of the lumbar plexus are intended for the parietes of the abdomen, and form a continuous series with the dorsal nerves, to which they are very analogous as it regards their distribution.*

The *great abdominal nerve* (*a*, *fig.* 270.) is the most external, or rather the highest of the branches which come from the lumbar plexus (it is the *superior musculo-cutaneous nerve* of Bichat); the terms *ilio-inguinal* and *ilio-scrotal*, which are generally applied to it, are derived from the fact of its giving a small cutaneous branch to the pubic region.†

It arises from the first lumbar nerve, of which it may be regarded as a continuation; it immediately perforates the psoas, becomes sub-peritoneal, runs in front of the quadratus lumborum obliquely downwards and outwards, through the sub-peritoneal adipose tissue, parallel to the twelfth dorsal nerve, and thus reaches the crest of the ilium to the outer side of the quadratus lumborum. It next passes obliquely through the aponeurotic attachments of the transversalis, runs along the crest of the ilium between that muscle and the obliquus internus, and divides into two branches, the *abdominal branch*, properly so called, and the *pubic* branch.

The *abdominal branch*, properly so called, runs inwards between the transversalis and the internal oblique, parallel to the abdominal branch of the twelfth dorsal nerve, with which it almost always anastomoses, and soon divides, like the lower intercostal nerves, into two filaments, one of which perforates the rectus, whilst the other, after having entered the sheath of that muscle, perforates it and ramifies upon the skin.

The *pubic branch* (*a*, *fig.* 292.) continues in the original course of the nerve: opposite the anterior superior spinous process of the ilium, and often much beyond that point, it receives an anastomotic twig from the small abdominal nerve (*b'*), and sometimes even the whole of that nerve, runs parallel to the femoral arch, at a variable distance above it, meets with the spermatic cord in the male, and the round ligament in the female, emerges from the anterior orifice of the inguinal canal (*a*, *fig.* 291.), is reflected outwards upon the superior angle of that orifice, and then expands into *internal* or *pubic filaments*, which are distributed to the skin of the pubes, and *external filaments* which supply the skin of the fold of the groin; this pubic branch sometimes divides behind the femoral arch into two filaments, which escape separately from the inguinal ring.

At the point where the great abdominal nerve reaches the crest of the ilium. it very frequently divides into two branches, a *gluteal cutaneous*, which crosses obliquely over the crest of the ilium, and an *abdominal*, properly so called, which is distributed in the manner just described; in this case the great abdominal nerve has an analogous distribution to that of the dorsal nerves.

The *small abdominal* or small musculo-cutaneous nerve (above *b*, *fig.* 290.), the second branch derived from the lumbar plexus counting from without inwards (the *middle musculo-cutaneous* of Bichat), is merely an accessory of the great abdominal nerve, sometimes arising from it, often applied to it, and always anastomosing with it. It crosses obliquely over the anterior surface of the quadratus lumborum, and then over the iliacus, and is sometimes directed obliquely outwards towards the anterior superior spine of the ilium, to join the pubic branch of the great abdominal nerve, with which it is blended; it

* The varieties which they present as to their number, origin, and divisions, render their description difficult; I shall point out the most important varieties as we proceed.

† I have frequently found the great abdominal branch divided into two distinct branches, which anastomosed upon the crest of the ilium, and then had a common distribution. I have seen the uppermost division lying so close to the twelfth dorsal nerve that it might have been taken for a branch of that nerve.

sometimes runs alone between the transversalis and internal oblique: having reached the middle of the femoral arch, it anastomes (*b′*, *fig.* 291.) by a single twig with the pubic branch of the great abdominal nerve, runs along the femoral arch below and parallel to that branch, and terminates in the same manner, that is to say, in the skin of the pubes and groin. I have seen it give off a small branch to the lower part of the rectus abdominis. The small abdominal nerve deserves the name of *ilio-scrotal* as much as the great abdominal. If this denomination is to be preserved, it might be called the *small ilio-scrotal.*

The Inguinal Branches.

The *external inguinal*, or *external cutaneous nerve* (*c*, *fig.* 290.), the third branch of the lumbar plexus, counting from without inwards (inguino-cutaneous *Chauss.*; inferior musculo-cntaneous, *Bichat*), is intended exclusively for the integuments of the external and posterior regions of the thigh. It generally comes off from the second lumbar nerve: I have seen it arise by a common trunk from the second and third lumbar nerves, and I have also seen it come off from the outer side of the crural nerve. It arises by one and often by two cords, which unite as they emerge from the psoas or within the substance of that muscle. In either case, the nerve passes obliquely through the back part of the psoas, crosses the iliacus, being bound down by a layer of fascia, and then gains the anterior superior spinous process of the ilium, below which it emerges (*c*, *fig.* 291.) from the abdomen, passing behind the femoral arch, and apparently increasing in size during its passage.

Below the femoral arch the nerve is sub-aponeurotic, or rather is situated in a sheath formed by the deepest layers of the fascia lata, and divides into two cutaneous branches (*c c*, *fig.* 292.), a *posterior* or *gluteal* *, and an *anterior* or *femoral.*

The *posterior* or *gluteal branch* turns very obliquely outwards, downwards, and backwards, crosses the tensor vaginæ femoris, and is distributed to the skin of the posterior region of the thigh. It is sometimes derived from the internal inguinal nerve, and then emerges from the abdomen on the outer side of the external inguinal nerve, crossing obliquely in front of it. When the great abdominal nerve (ilio-scrotal of authors) gives off a cutaneous gluteal branch, there is only a trace of this posterior branch of the external inguinal nerve.

The *anterior* or *cutaneous branch* divides into two others, which diverge at an acute angle: one is *external*, the other *internal*; the *external* branch gives off a series of filaments which pass backwards and downwards, forming loops with their concavities turned upwards, and is then lost towards the lower third of the thigh: its place is then supplied by the *internal* branch, which had at first descended vertically, but now turns outwards and backwards, and is distributed over the outer and fore part of the knee.

These several divisions of the external inguinal nerve lie in contact with the femoral fascia, and their ultimate filaments are applied to the skin.

The *internal inguinal nerve* (branche genito-crurale, *Bichat*; rameau sous-pubien, *Chauss.*; *b*, *fig.* 290.), arises from the second lumbar nerve, passes directly forwards through the psoas, from which it emerges at the side of the bodies of the lumbar vertebræ, runs vertically downwards upon the anterior surface of the muscle covered by a very thin layer of fascia, and having arrived within a greater or less distance from the femoral arch, divides into two branches, an *internal* or *scrotal*, and an *external* or *femoral cutaneous branch* (*e*). Not unfrequently this division takes place as the nerve emerges from the psoas. Sometimes indeed the genito-crural nerve is double, but this

* Not unfrequently the external inguinal nerve gives off a third and very small internal branch, which lies immediately in contact with the skin of the anterior region of the thigh, and may be traced as far as the lower third of that region. This branch always anastomoses with a cutaneous branch of the crural nerve.

arises merely from its early subdivision. During its course, the internal inguinal nerve is crossed by the ureter and covered by the spermatic vessels.*

The *internal* or *scrotal branch* (*e*, *fig.* 290.) crosses over the front of the femoral artery, gains the internal orifice of the inguinal canal, crosses the epigastric artery, and before entering the inguinal canal, gives off several filaments which are reflected upwards, and dip into the substance of the internal oblique and transversalis; the scrotal branch is placed below the spermatic cord, from which it is perfectly distinct, runs with it through the whole length of the inguinal canal (*b*, *fig.* 291.), rests upon the reflected portion of the femoral arch or Gimbernat's ligament, and emerges from the external orifice of the inguinal canal, opposite the lower end of the external pillar: at this point it is reflected, passes vertically downwards behind the cord, and ramifies in the skin of the scrotum of the male, and of the labia majora in the female.

The *femoral cutaneous branch* gains the crural ring; but before entering the ring, it gives off a great number of very delicate filaments, which are reflected upwards behind the arch, to be distributed to the lower part of the psoas-iliac and transverse muscles: it then passes through the crural ring, in contact with its outer angle, and crosses the circumflex ilii artery at its origin, just as we have shown that the scrotal nerve crosses the epigastric artery; after leaving the crural ring (*e*, *figs.* 291, 292.), it lies beneath the fascia, but soon becomes subcutaneous, anastomoses with a cutaneous branch of the crural nerve, and may be traced beyond the middle of the thigh.†

I have already stated, in describing the external inguinal nerve, that the posterior or gluteal cutaneous branch of the external inguinal nerve is often given off by the internal inguinal nerve. In that case this branch runs outwards, crosses the external nerve at a very acute angle under the femoral arch, and escapes from below the arch on the outer side of that nerve to turn round the tensor vaginæ femoris. Not unfrequently the filaments for the lower part of the internal oblique and transverse muscles arise by one or more distinct branches.

The Terminal Branches of the Lumbar Plexus.

These are three in number, viz. the *obturator nerve*, the *crural nerve*, and the great communicating branch between the lumbar and sacral plexus, called the *lumbo-sacral trunk* or *nerve*, which I regard as a dependence of the sacral plexus.

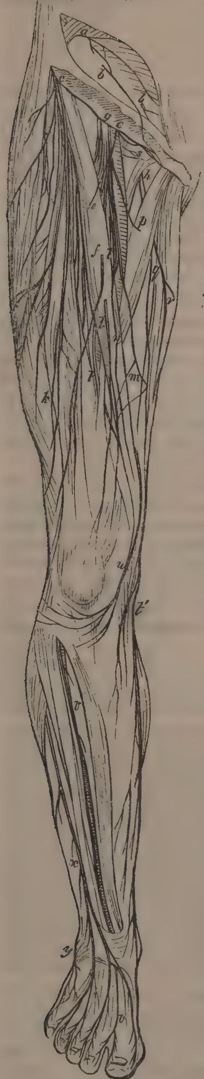
The Obturator Nerve.

The *obturator nerve* (*h*, *fig.* 290.), which is distributed exclusively to the external obturator muscle, to the three adductors of the thigh, and to the gracilis, is the smallest of the terminal branches of the lumbar plexus; it arises from the third and fourth lumbar nerves by two equal branches, which unite at an acute angle; it perforates the psoas, passes under the angle of bifurcation of the common iliac artery and vein, runs along the inner surface of the psoas, crosses very obliquely over the sides of the brim of the pelvis, and is then placed below the external iliac vessels, with which it forms an acute angle, and above the obturator artery: throughout the whole of this course, it is enveloped in the subperitoneal cellular tissue of that region, and thus flattened and enlarged, reaches the internal orifice of the obturator or subpubic canal, on emerging from which it expands into diverging branches (*h*, *fig.* 291.) for the adductors and the gracilis muscle of the thigh.

* Sometimes a small filament comes off from the genito-crural nerve whilst it is still within the substance of the psoas, descends vertically on the inner side of this nerve, gives off a filament which is lost upon the external iliac artery, and then again becomes united with the nerve from which it had been given off.

† In order to assist the memory, by connecting these nerves with important parts, I am in the habit of calling the femoral cutaneous branch of the internal inguinal nerve the *branch of the crural ring*, and the scrotal branch, the *branch of the inguinal canal*. The scrotal branch may be cut in relieving the stricture in inguinal hernia by the division of Gimbernat's ligament; and the femoral cutaneous branch may be wounded when the external angle of the crural ring is divided for the relief of femoral hernia.

Fig. 291.



Collateral branch. The obturator nerve gives off no branch in the pelvis: during its passage through the obturator or subpubic canal it gives two filaments to the *obturator externus;* one of these penetrates the upper border of the muscle, and the other enters at its anterior surface.* The obturator internus receives no filament from the obturator nerve.

Terminal branches. These are four in number †; three of them, constituting a *superficial set,* pass under the pectineus, and are distributed as follows: the *internal* to the gracilis, the *external* to the adductor longus, and the *middle* to the adductor brevis; the fourth, which is more *deeply* seated, belongs to the adductor magnus.

The *branch for the gracilis* expands, as it enters the muscle, into several filaments, the largest of which (*r*, *fig.* 291.), runs for some distance upon the internal surface of the muscle before terminating in it.

The *branch for the adductor longus* enters the upper border and deep surface of the muscle: a rather large division (*q*) of this branch, taking a different course, passes sometimes in front of and sometimes behind the muscle, which is crossed by the nerve in the first case, and perforated by it in the second; the nerve then divides into several filaments, some of which anastomose with the accessory branch (at *m*) of the internal saphenous nerve, whilst another anastomoses with the saphenous nerve itself, and a third terminates in the synovial membrane of the knee joint: this is an articular nerve; it may unite with the articular branch of the nerve for the vastus internus. The anastomotic division of the branch for the adductor longus is sometimes as large as the muscular branch itself.‡

The *branch for the adductor brevis* crosses the upper border of that muscle, expands upon it, but does not enter it until it reaches the middle; there is almost always an anastomotic twig, which joins the internal saphenous branch of the crural nerve.§

* [It also gives off in this situation articular filaments to the hip joint; these are small or absent when the articular branches of the accessory to the obturator are large.]

† [Before dividing into its terminal branches the obturator is joined by its accessory nerve, see notes, *infrà*); it supplies a separate branch to the pectineus when that from the accessory nerve is wanting.]

* See note, p. 1072.

§ In a great number of subjects I have found a small nervous cord, which sometimes came off from the third lumbar nerve, sometimes from the obturator itself, and which may be called the *accessory of the obturator nerve*, or the *nerve of the coxo-femoral articulation;* it perforates the psoas to reach its inner surface, runs parallel to and above the obturator nerve, gains the pubes, which it crosses on the inner side of the ilio-pectineal eminence, with which it is in contact, dips beneath the pectineus, and anastomoses with the internal saphenous nerve, passing into the angle of bifurcation of the femoral artery, where it gives off the profunda. Opposite the pubes it gives off several branches which perforate the fibrous capsule of the coxo-femoral articulation, and are distributed to the synovial membranes. [This small accessory nerve was first described by Schmidt. As it passes under the pectineus it partially supplies that muscle; its anastomotic branch is described as uniting with the obturator nerve beneath the pectineus, and not with the internal saphenous (see also notes, pp. 1072. 1075.). The articular branch was believed by Schmidt to end in the fat near the acetabulum. When the accessory nerve is small, the articular filaments and the branch to the pectineus are replaced by others from the trunk of the obturator itself.

The *fourth branch* or *branch for the adductor magnus* is the *deepest*; it passes between the adductor brevis and magnus, and ramifies in the last-mentioned muscle.*

The Crural Nerve.

The *crural nerve* (*g*, *fig.* 290.) is the external terminal branch of the lumbar plexus; the third and fourth lumbar nerves are almost entirely devoted to the formation of this large branch, which supplies all the muscles of the anterior region of the thigh, and the integuments of the anterior regions of the thigh, leg, and foot.

After emerging from the psoas, the crural nerve is lodged in the groove between the psoas and iliacus; it escapes from the pelvis with this muscle, in the sheath of which it is contained: having arrived below the femoral arch (*g*, *fig.* 291.), it turns slightly outwards, becomes flattened and widened, and immediately divides into a great number of diverging branches. The nerve sometimes bifurcates, and then gives off these different branches.

Relations. In the iliac fossa, the crural nerve is covered by the iliac fascia, and is separated by the psoas from the external iliac artery and vein. Opposite the femoral arch it always occupies the groove between the psoas and iliacus, and is situated on the outer side of the femoral artery, being separated from the vessel by the psoas, which is very narrow at that point. It is of importance to remark that the crural nerve is not contained in the sheath of the femoral vessels, but is separated from them by the iliac fascia (see Vol. I. *fig.* 136.).

Collateral branches. In the pelvis, the crural nerve gives off from its outer side a great number of small branches (*iliac branches*), which enter separately into the iliacus muscle, after having run for some distance obliquely downwards and outwards upon the surface of that muscle. Only *one* branch enters the psoas. One of the branches for the iliacus is very long, and descends vertically in front of that muscle, into which it enters, after having turned round its outer border. I have already said that the external inguinal nerve (*inguino-cutaneous* of authors) not unfrequently arises from the crural nerve.

In the pelvis the nerve has been seen to give filaments to the levator ani. (Schmidt, *De Nervis Lumbalibus eorumque Plexu*, 1794; Dr. Alex. Thomson, *Lond. Med. and Surg. Journal*, Nos. 94, 95.; Ellis, *Demonstrations of Anatomy*).]

* [In the dissections of Schmidt, Thomson, and Ellis, the branches of the obturator nerve were found to have a much more extensive distribution than that described in the text. According to their observations, one of the *superficial* branches, which is named the *long cutaneous* nerve (*q*, *fig.* 291.), and which corresponds to the anastomotic division of the branch for the adductor longus, gives off cutaneous branches (*q*, *fig.* 292.) which perforate the fascia to the inner side of the sartorius muscle, and supply the skin on the inner part of the thigh; it also gives anastomotic branches to the plexus (*m*, *fig.* 291.) formed in the middle of the thigh, and sometimes an articular filament to the knee (these anastomotic and articular branches are described in the text, p. 1071.); it then ends in a descending cutaneous branch which perforates the fascia near the knee (*r*, *fig.* 292.), communicates with the internal cutaneous and internal saphenous nerves, and is distributed to the skin on the inner and back part of the two upper thirds of the leg. The *deep* branch of the obturator gives off within the upper part of the adductor magnus an articular filament destined for the knee joint; this filament descends in the substance of the adductor near the linea aspera, and enters the popliteal space, either by perforating the tendinous insertion of the muscle about its lower third, or by coming forwards on the front of that insertion, and then passing backwards through the opening for the femoral artery: having reached the popliteal space, it surrounds the artery with small filaments, and enters the back part of the knee joint.

The cutaneous branches just stated to be given off by the superficial part of the obturator to the thigh and leg, and the articular filament given by the deep branch of the obturator to the knee joint, correspond in *their distribution* with the three collateral branches described by M. Cruveilhier (pp. 1075-6.) as arising from the internal saphenous nerve *after it has received a remarkable branch of origin from the obturator nerve*, opposite to the commencement of the profunda artery: these collateral branches of the internal saphenous were never met with in Mr. Ellis's dissections. In some cases, then, it seems that part of the obturator joins the internal saphenous, which afterwards gives off cutaneous branches to the thigh and leg, and an articular filament to the knee; in other cases, again, the obturator does not join the internal saphenous, the above-mentioned branches arise directly from the obturator, and the internal saphenous gives no collateral branches.]

Of the *terminal branches of the crural nerve* there are two which arise in *front* of the others; these are, the *musculo-cutaneous nerve*, and the *small nerve for the sheath of the femoral vessels.** The other branches are, proceeding from without inwards, the *branch for the rectus*, the *branches for the vastus externus*, *the branches for the vastus internus*, and the *cutaneous branch*, called the *internal saphenous* nerve.

The Musculo-cutaneous Crural Nerve.

This nerve passes obliquely downwards and outwards between the sartorius and the psoas and iliacus, and immediately expands into *muscular branches*, distributed exclusively to the sartorius, and *cutaneous branches.*

The *muscular branches* may be divided into the *short*, which enter the upper part of the sartorius, and the *long*, which run for some distance upon the deep surface of that muscle, before passing into it.

The *cutaneous branches* are three in number; two of them perforate the sartorius at different points, and may be called *perforating branches.* I shall call the third the *accessory branch of the internal saphenous nerve.*

The *superior perforating cutaneous* or *middle cutaneous nerve* (*f*, *fig.* 291.) passes very obliquely through the upper part of the sartorius, and often, as it emerges from that muscle, anastomoses with a branch from the internal inguinal (genito-crural) nerve; it then passes vertically downwards, parallel to and on the inner side of the external inguinal (external cutaneous) nerve; it lies in contact with the femoral fascia (*f*, *fig.* 292.), or rather, is contained in a proper fibrous sheath. During its course, the superior perforating cutaneous nerve gives off internal and external cutaneous filaments, and bifurcates opposite the middle of the thigh into two branches of equal size, which run parallel to each other, gradually diminishing in size, and may be traced down to the skin over the patella.

The *inferior perforating cutaneous* or *internal cutaneous nerve* (*l*, *fig.* 291.) runs along the inner border of the sartorius, inclosed in its sheath, passes obliquely through the muscle at the middle of the thigh, but perforates the femoral fascia much lower down (*l*, *fig.* 292.); it descends vertically, in contact with that fascia, and having arrived opposite the internal condyle of the femur, is reflected forwards upon itself, describing a loop with the concavity turned upwards; it thus gains the patella, runs between the skin and the subcutaneous bursa, and expands into a number of diverging filaments, which anastomose with the reflected branch (*l l*) of the internal saphenous nerve on the inner side of the patella. A small filament often remains in the sheath of the sartorius, anastomoses upon that muscle with a branch from the accessory of the internal saphenous nerve, perforates the sheath of the sartorius opposite the knee, and anastomoses on the inner side of the joint with the reflected branch of the internal saphenous.

The *accessory cutaneous branch of the internal saphenous nerve* arises from the musculo-cutaneous nerve on the inner side of the perforating branches, descends vertically, and divides into two branches. The smaller of these is *superficial* (*n*, *fig.* 291.); it enters the sheath of the sartorius, runs along the inner border of the muscle, escapes from the sheath below the middle of the thigh, crosses the adductor and the gracilis, and is in contact with the internal saphenous vein until it reaches the inner side of the knee, where it anastomoses with the internal saphenous nerve. The other branch, the *satellite nerve of the femoral artery*, crosses obliquely over the nerve for the vastus internus and the internal saphenous nerve, and is situated in front of the latter, runs along the femoral artery, covering the lower fourth of that vessel, and crosses very obliquely over it, then passes over the tendon of the adductor magnus, and having reached the fibrous ring through which the femoral artery passes, it expands into a

* [The crural nerve also gives some small branches (*s*, *fig.* 292.), which pass inwards behind the femoral vessels, enter the pectineus muscle, and sometimes the psoas also.]

great number of filaments, of which one anastomoses with the preceding branch (n), another joins the obturator nerve (at m), and a third unites with the internal saphenous nerve; a sort of plexus is thus formed which gives origin to several nerves that cross obliquely over the gracilis to be distributed to the skin upon the posterior region of the leg.

The Small Nerve for the Sheath of the Femoral Vessels.

This branch, which often comes off separately from the lumbar plexus, is situated, like the musculo-cutaneous, in front of the other branches of the crural nerve; it then expands into a great number of very slender filaments which surround the femoral artery and vein. Two of these filaments, of which one passes in front of and the other behind the femoral artery, unite to form a small nerve (p, *fig.* 291, 292.) that escapes by the opening (p) for the internal saphenous vein, and accompanies the vein for a great part of its course. Not unfrequently, the filaments which have passed between the artery and vein perforate a lymphatic ganglion. Two other filaments are distributed to the adductor brevis and adductor longus; several of them turn round the deep femoral artery and vein, to become subcutaneous, and anastomose with other accompanying branches of the femoral vessels, and more particularly with the internal saphenous nerve.

This small branch presents many varieties. I have seen it arise separately from the fourth lumbar nerve, and it then runs along the anterior surface of the crural nerve.

The Nerve for the Rectus Femoris.

The *nerve for the rectus femoris* arises on the inner side of the preceding, enters the upper part of the deep surface of the muscle, and divides into a *superior* or short branch, which passes horizontally outwards in the substance of the muscle, and an *inferior* or long branch, which lies in contact with its inner border and enters the muscle at the middle of the thigh.

The Nerve for the Vastus Externus.

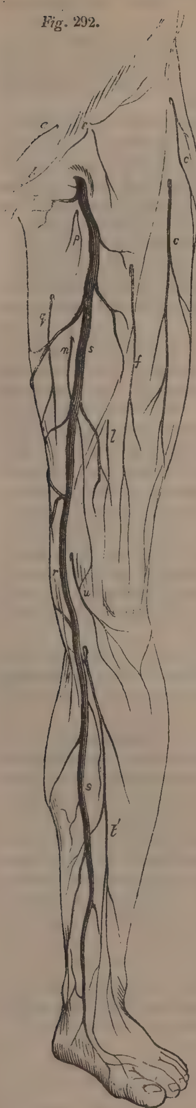
The *nerve for the vastus externus* sometimes arises by a common trunk with the preceding, passes obliquely downwards and outwards beneath the rectus, to which it gives a filament, and then divides into two branches: one of these immediately enters the upper part of the vastus externus, and gives off, before penetrating it, a cutaneous branch which, perforates the fascia lata and lies in contact with the skin of the external region of the thigh: the other is longer, dips between the vastus externus and internus, and enters the middle of the former muscle. This last branch almost always gives off a small twig to the vastus internus.

*The Nerves for the Vastus Internus.**

These are two in number; the one is *external*, and descending vertically, enters that portion of the vastus internus which corresponds to the anterior surface of the femur (the crureus of authors), and may be traced as far as the lower part of the muscle: this nerve furnishes several *periosteal* and *articular filaments*; the other is *internal* and much larger; it often arises by a common trunk with the internal saphenous nerve, runs vertically downwards in front of the vastus internus, parallel to and on the outer side of the femoral artery, being in contact with that vessel above, but separated from it below, where it enters the vastus internus. Before penetrating it, it gives off a very remarkable *articular* and *periosteal branch*, which runs along the surface of the

* It will be remembered that, according to my views, the portion of the triceps which is called the *crureus* is not distinct from the vastus internus (see MYOLOGY).

Fig. 292.



muscle, to the aponeurosis of which it is applied*: opposite to the knee joint it is reflected forwards, perforates the thick fibrous layer which invests the inner side of the joint, and divides into two filaments, of which one, the *articular*, is lost behind the ligamentum patellæ in the quantity of adipose tissue which is found there, whilst the other, or the *periosteal*, gains the anterior surface of the patella and is lost in the periosteum. This last filament is reinforced upon the inner border of the patella by another which passes out from the substance of the vastus internus.

The Internal Saphenous Nerve.

The *internal saphenous nerve* (*t t'*, *fig.* 291.), the satellite nerve of the femoral artery in the thigh, and of the internal saphenous vein in the leg, is at first situated on the outer side of the artery, but soon passes in front of that vessel, and is contained in the same fibrous sheath; when the artery passes through the tendon of the adductor magnus to enter the popliteal space the nerve continues its vertical course in front of that tendon, and crossing it very obliquely from before backwards, gains the back of the internal condyle of the femur, situated in front of the tendon of the gracilis, and separated from the skin by the sartorius; it then divides into two terminal branches (*u*, *t'*, *figs.* 291, 292.). This division often takes place as the nerve is crossing the tendon of the adductor magnus.

Collateral branches. At its upper part the internal saphenous nerve receives from the obturator nerve a remarkable branch of origin, which passes from behind forwards in the angle formed by the femoral artery and the profunda.† It then gives off from its inner side, at the middle of the thigh, a *cutaneous femoral branch*, which passes between the sartorius and the gracilis, runs backwards and downwards, and is distributed to the skin of the posterior and internal region of the thigh. Several filaments continue their course to the inner and back part of the knee, anastomose with some branches given off from the saphenous nerve in the leg, and are distributed to the skin of the internal and posterior region of the leg.

At the point where the femoral artery perforates the adductor magnus, the internal saphenous nerve gives off a *second* or *tibial cutaneous branch*, which passes between the sartorius and gracilis, turns round the inner border of the latter muscle, passes vertically downwards, parallel to the saphenous nerve, and divides into several filaments, some of which anas-

* [In this situation it sometimes receives the articular filament of the anastomotic or long cutaneous branch of the obturator nerve.]

† [This junction of part of the obturator with the internal saphenous nerve was never seen in the dissections of Mr. Ellis, nor did the saphenous give any collateral branch in the thigh; but branches corresponding in their distribution to the three collateral branches described in the text arose from the obturator itself (see also note, p. 1072.).]

tomose with that nerve, while the others are distributed to the skin upon the internal and posterior region of the leg.

In the sheath of the adductor magnus the saphenous nerve gives off an *articular filament*, which passes vertically downwards in the substance of the internal intermuscular septum, gains the knee joint, perforates the fibrous layer, and may be traced into the synovial adipose tissue.*

Terminal branches. The *anterior*, *reflected*, or *patellar branch* (*u*, *figs.* 291, 292.) perforates the sartorius † opposite to the back of the internal condyle, is reflected forwards and downwards in a flattened form upon the inner side of the knee joint, parallel to and above the tendon of the sartorius, and expands widely into *ascending filaments*, which pass in front of the ligamentum patellæ, and turn round the lower and then the outer borders of the patella ; into *descending filaments*, which cross obliquely over the crest of the tibia, and ramify in the skin which covers the external region of the leg; and into *middle filaments*, which occupy the space between the two preceding sets ; they are all distributed to the skin, and several of them anastomose with the cutaneous filaments upon the external region of the patella.

The *posterior* or *straight branch* (*t'*) is larger than the preceding, and continues in the original course of the nerve; it almost always receives an anastomotic branch from the obturator nerve, passes in front of the tendon of the gracilis, then between the sartorius and that tendon, which it crosses very obliquely, to meet the internal saphenous vein (*s*), whose direction it then follows: having arrived opposite the junction of the three upper fourths with the lower fourth of the leg, it divides into two branches, the one, *posterior* and smaller, passes vertically downwards in front of the internal malleolus, upon which it ramifies; some of the filaments reaching as far as the skin upon the inner side of the sole of the foot; the other branch, which is *anterior* and larger, runs along the internal saphenous vein, like it, is situated in front of the internal surface of the tibia, then in front of the internal malleolus, and expands into *articular branches*, which enter the tibio-tarsal articulation, and into cutaneous filaments, which ramify in the skin upon the inner side of the tarsus.

The following are the relations of the saphenous nerve with the internal saphenous vein — the nerve is at first placed in front of the vein, then crosses obliquely under it to get behind it, and lastly it again returns to its position in front of the vessel.

During its course along the leg the posterior branch of the saphenous nerve gives off some internal and some external branches: the *internal branches* are very small; the upper ones anastomose with the *tibial cutaneous branch* of the trunk of the internal saphenous nerve, and concur with it in supplying filaments to the skin of the back of the leg. The *external branches*, three or four in number, are large, and in this respect diminish from above downwards; their direction is obliquely downwards and outwards, in front of the tibia, which they cross; their course is a long one, and they are distributed extensively to different portions of the skin of the leg. All these divisions are parallel to each other, and to the anterior reflected or patellar branch of the saphenous nerve.

* See note, p. 1072.

† The sartorius is, therefore, perforated in succession by three cutaneous branches, namely, two perforating branches from the musculo-cutaneous nerve, and one from the internal saphenous.

THE ANTERIOR BRANCHES OF THE SACRAL NERVES.

Dissection. — Enumeration. — The Sacral Plexus. — Collateral Branches, viz. the visceral nerves — the muscular nerves — the inferior hæmorrhoidal — the internal pudic and its branches — the superior gluteal nerve — the inferior gluteal, or lesser sciatic nerve — the nerves for the pyramidalis, quadratus femoris, and gemelli. — Terminal Branch of the Sacral Plexus or the Great Sciatic Nerve. — The external popliteal and its branches — the peroneal saphenous, cutaneous, and muscular branches — the musculo-cutaneous — the anterior tibial. — The internal popliteal and its branches — the tibial or external saphenous — muscular and articular branches — the internal plantar — the external plantar. — Summary of the nerves of the lower extremity. — Comparison of the nerves of the upper with those of the lower extremity.

Dissection. Make an antero-posterior section of the pelvis, as in dissecting the internal iliac artery.

The *anterior branches of the sacral nerves* (26 to 31, *fig.* 268.), which are six in number, communicate with the sacral ganglia of the sympathetic, after they have emerged from the sacral foramina, and present the following arrangement: —

The *first nerve* (1, *fig.* 290.), which is very large, passes obliquely downwards and outwards, in front of the pyriformis, and is joined at a very acute angle by the lumbo-sacral nerve (*i*) to assist in the formation of the sacral plexus.

The *second nerve*, which is as large as the preceding, passes much more obliquely downwards and outwards, and immediately enters the sacral plexus.

The *third nerve* (3), which is scarcely one fourth as large as the second, passes more horizontally outwards to enter the sacral plexus. A considerable interval, in which is a large part of the pyriformis, separates it from the second nerve. A filament stretched in front of this muscle passes from the second to the third sacral nerve.

The *fourth nerve* (4), which is only one third the size of the third, is divided and distributed in the following manner — one of its divisions assists in forming the sacral plexus; it gives off several visceral branches, which enter the hypogastric plexus; it communicates with the fifth sacral nerve by another division; it gives off one or two branches to the coccygeus muscle; and, lastly, it gives a cutaneous coccygeal branch, which runs along the border of the sacrum, penetrates the great sacro-sciatic ligament, crosses that ligament very obliquely, and turns round its lower edge, perforates the coccygeal attachments of the glutæus maximus, passes very obliquely through the muscle, gives branches to it, and then ends in the integuments.

The *fifth and sixth nerves*, which have no connexion with the sacral plexus, are extremely small; the fifth is not more than half the size of the fourth; the sixth is so very slender a filament, that it has often escaped the notice of anatomists, and hence the incorrect but prevalent opinion, that there frequently exist only five sacral nerves.

The *fifth nerve*, at its exit from the anterior sacral foramen, divides into an *ascending branch*, which communicates with the fourth, and a *descending branch*, which passes directly downwards to anastomose with the sixth, of which it appears to form the ascending branch.

The *sixth nerve* consists of a mere filament, which divides, while still contained within the sacral foramen, into an *ascending* or anastomotic branch, which is merely the descending branch of the fifth; a *descending* or *inferior coccygeal branch*, which passes vertically downwards along the coccyx in the substance of the sacro-sciatic ligament, and is distributed to the skin; and certain *external branches*, which perforate the sacro-sciatic ligament, and terminate in the glutæus maximus.

The Sacral Plexus.

The *sacral plexus* (*fig.* 290.) is formed by the four upper sacral nerves (1 to 4) and the lumbo-sacral nerve (*i*) from the lumbar plexus; the three superior sacral nerves pass entirely into this plexus; the fourth nerve only sends one of its divisions to it. The lumbo-sacral trunk or nerve, which emanates from the lumbar plexus, is formed by the whole of the fifth lumbar nerve added to a branch from the fourth. This great nervous trunk establishes a free connexion between the lumbar and sacral plexuses, which in fact constitute only one plexus, which may be called the lumbo-sacral. I would here recall to mind that there is a precisely similar arrangement with regard to the cervical and brachial plexuses, to which the lumbar and sacral plexuses have an undoubted analogy.

The sacral plexus is distinguished by its simplicity from most other plexuses, which are always more or less complicated. It is formed by the convergence of five cords towards the sciatic notch. As the lumbo-sacral cord is vertical, and the third and fourth sacral nerves are horizontal, it follows that the form of the sacral plexus resembles a triangle, the base of which measures the entire length of the sacrum, while its apex corresponds to that portion of the sciatic notch which is situated above the spine of the ischium. The great sciatic nerve (*s*) is the continuation of this plexus, which, as Bichat judiciously remarked, is merely the sciatic nerve itself flattened from before backwards, the intricacy of arrangement so evident in the plexus representing that which exists in all nervous cords.

The following are the relations of the sacral plexus: it rests behind upon the pyriformis, and it corresponds in front to the internal iliac vessels, from which it is separated by a layer of fascia: these vessels also separate the plexus from the rectum and peritoneum.

Of the *collateral branches* some are *anterior*, namely, the visceral nerves, which enter the hypogastric plexus; the nerve for the levator ani; the nerve for the obturator internus; the internal pudic nerve: the other collateral branches are *posterior*, namely, the superior gluteal nerve; the inferior gluteal or lesser sciatic nerve; the nerve for the pyriformis; the nerve for the gemelli; and the nerve for the quadratus femoris. The great sciatic nerve is the only *terminal branch* of the sacral plexus.

The Collateral Branches of the Sacral Plexus.

The Visceral Nerves.

Dissection. After having made a section of the pelvis at one side of the symphysis, turn the bladder and the rectum over to the same side; carefully detach the peritoneum, which is reflected from the pelvis upon these viscera; lacerate the cellular tissue to reach the branches given off from the fourth nerve; and then trace the rectal and visceral nerves, following the annexed description. It is advantageous to empty the large veins of the pelvis, and to soak it in water for some time previously to dissecting these nerves.

The *visceral nerves* do not, properly speaking, come from the sacral plexus, but rather directly from the fourth and fifth sacral nerves; they are three or four in number, and pass upwards upon the sides of the rectum and bladder in the male, and of the rectum, vagina, and bladder, in the female; some of them are distributed directly to those organs, but the greater number (*y*, *fig.* 302.) enter the hypogastric plexus (*m*), which will be described with the sympathetic system.

The Nerves for the Levator Ani.

Besides several rectal and vesical filaments which go to the levator ani, this muscle receives two filaments directly from the fourth sacral nerve (4 *fig.* 290.),

the larger of these filaments enters the middle of the muscle; the other, which is smaller, passes upon the sides of the prostate in the male, and of the vagina in the female, and terminates in the anterior portion of the muscle.

The Nerve for the Obturator Internus.

It arises from the anterior part of the sacral plexus, and more particularly from that portion which belongs to the lumbo-sacral cord and the first sacral nerve; it passes immediately behind the spine of the ischium, is reflected forwards through the small sciatic notch, and expands into three diverging branches, which are distributed within the muscle. In order to expose this nerve the lesser sacro-sciatic ligament may be divided.

The Inferior Hæmorrhoidal Nerve.

This nerve, which is intended for the sphincter ani and the adjacent skin, arises (from 4, *fig.* 290.) on the inner side of the internal pudic nerve, of which it is sometimes a branch; passes, like that nerve, behind the spine of the ischium, and then between the two sacro-sciatic ligaments, reaches the front of that portion of the glutæus maximus which projects below the great sacro-sciatic ligament, communicates with the superficial nerve of the perineum, gains the side of the rectum, and opposite the upper border of the sphincter expands into a great number of branches; of these, some are *anterior*, and often anastomose with one of the divisions of the superficial perineal nerve; others are *median*, and pass upon the sides of the sphincter ani as far as the skin, in which they terminate; lastly, others are *posterior*, and proceed to the back part of the sphincter. The hæmorrhoidal or anal nerve is sometimes distributed exclusively to the skin round the anus; it may then be named the *anal cutaneous nerve.*

The Internal Pudic Nerve.

Dissection. It is convenient to commence the dissection of this nerve from within outwards, by dividing the lesser sacro-sciatic ligament, and separating the obturator fascia from the obturator internus muscle. The superior branch of the nerve upon the dorsum of the penis may then be traced without taking it away. The perineal branches must then be very carefully dissected, and the continuity of these branches with those already dissected within the pelvis should be made out.

The internal pudic nerve (*d*, *fig.* 293.) arises from the lower border of the flattened band formed by the nerves of the sacral plexus opposite to their junction; it passes behind the spine of the ischium, and then enters the ischio-rectal fossa through the lesser sciatic notch, that is between the two sacro-sciatic ligaments, on the inner side of the internal pudic artery, and divides into two branches, (*l*, *fig.* 290.) the *inferior branch* or *perineal nerve*, and the *superior* or *deep branch*, or the *dorsal nerve of the penis.*

The Perineal Nerve.

The *inferior branch* or *perineal nerve* corresponds to the trunk of the internal pudic artery and to all its divisions, excepting the dorsal artery of the penis. It is the true continuation of the nerve, and accompanies the trunk of the internal pudic artery, being situated below that vessel; it runs forwards and then upwards between the obturator internus and the obturator fascia, describes a curve having its concavity directed upwards, and placed on the inner side of the tuberosity of the ischium, perforates the obturator fascia, opposite to the junction of the tuberosity with the ascending ramus of the ischium, and immediately divides into two branches, an *inferior* or anterior superficial perineal, which corresponds to the superficial artery of the perineum, and a *superior*, which corresponds to the artery of the bulb, but which has a much more extensive distribution; I shall call it the *bulbo-urethral nerve.*

The collateral branches of the perineal nerve. During its course, the perineal

nerve gives off a branch which might be called the *external perineal* (*posterior superficial perineal*); this branch perforates the great sacro-sciatic ligament, passes by the internal surface of the tuberosity of the ischium, turns inwards and downwards, and then beneath the tuberosity, runs along the crus of the corpus cavernosum, and is lost in the dartos and scrotum in the male, and in the substance of the labia majora in the female. I have seen this nerve give a branch to the coccygeus, and two branches to the sphincter.

This external perineal branch moreover presents many varieties. In some cases it terminates by anastomosing with the superficial branch of the perineum. In one case, in which the external perineal branch was very small, it was reinforced by a branch from the inferior gluteal or lesser sciatic nerve, which crossed the outer side of the tuberosity of the ischium, and united, in front of that tuberosity, with the external perineal branch.

The terminal branches of the perineal nerve. The *superficial* (*anterior superficial*) *perineal nerve* follows the superficial artery of the perineum, passes like it obliquely inwards and forwards, through the cellular interval between the ischio-cavernosus and bulbo-cavernosus, receives a rather large filament from the external perineal branch, and almost always divides into several remarkably long filaments which pass through the dartos, some reaching the bottom of the scrotum, whilst others, running along the lower surface of the penis, are distributed to the skin of that organ, and may be traced as far as the prepuce.

The *bulbo-urethral nerve*, the second terminal branch of the perineal nerve, passes above and sometimes through the fibres of the transversus perinei muscle, supplies some small branches to the anterior part of the compressor urethræ and the posterior part of the bulbo-cavernosus, furnishes a bulbar branch which dips into the substance of the bulb, and then expands into very delicate filaments on the corpus spongiosum.

The Deep Branch of the Internal Pudic, or the Dorsal Nerve of the Penis.

This is the highest of the terminal divisions of the internal pudic nerve, and corresponds to the deep branch of the internal pudic artery. It is at first applied, together with that vessel, against the internal surface of the tuberosity of the ischium, and passing upwards between the levator ani and obturator internus, gains the arch of the pubes; it then runs forwards among the subpubic veins through the several ligamentous structures below the arch, and reaches the dorsum of the penis, where it is situated at the side of the suspensory ligament. Having now become the dorsal nerve of the penis, it runs along that organ in the median line, like the dorsal artery, but superficially to that vessel, and divides into an *internal* and an *external branch*.

The *internal branch*, or *branch for the glans penis*, continues in the original course of the nerve upon one side of the median line, becomes more deeply seated as it runs forwards, but without entering the corpus cavernosum, and thus arrives at the corona glandis; at this point it expands and passes deeply between the base of the glans and the corpus cavernosum, gives no filament to the latter, but is entirely distributed to the glans, penetrating that part by extremely delicate filaments, which traverse the spongy tissue, and may be traced, at least in a great measure, to the papillæ on the surface of the glans.

The *external* or *cutaneous branch*, which is more superficial, comes off from the preceding at a very acute angle, passes obliquely upon the sides of the penis, and expands into a number of very long and slender filaments, some of which lie in contact with the corpus cavernosum, and supply it with very slender filaments, whilst others run in the subcutaneous cellular tissue, and are distributed to the skin of the penis; a considerable number terminate in the prepuce. The external branch of the dorsal nerve of the penis supplies the skin upon the three upper fourths of the circumference of the penis. The perineal branches supply that of the lower fourth. I have not found any branch of the internal pudic nerve corresponding to the artery of the corpus cavernosum.

In the female, when this nerve reaches the clitoris, it becomes very small; it passes under the arch of the pubes, between it and the crus of the clitoris; it runs along that crus, becomes curved like the clitoris itself, upon the side of which it expands into filaments, and then ramifies in the substance of that organ; several of the filaments run forwards to the skin of the anterior part of the labia majora.

The superficial perineal branch passes between the constrictor muscle and the bulb of the vagina, and then terminates in these parts.

The internal pudic nerve in the female does not appear to me to be half the size of the internal pudic nerve of the male. In one case I found that it consisted only of the branch for the clitoris, the superficial branch being supplied by the inferior gluteal nerve.

The Superior Gluteal Nerve.

The *superior gluteal nerve*, which is intended for the glutæus medius and minimus, and the tensor vaginæ femoris, arises from the back of the lumbo-sacral trunk, before its junction with the first sacral nerve. I have seen it arising by two roots, of which one came from the lumbo-sacral nerve and the other from the posterior surface of the plexus: it emerges from the pelvis (*a*, *fig.* 293.) by the upper and fore part of the great sciatic notch, in front of the pyriformis, is reflected upon this notch to pass between the glutæus medius and minimus, and divides into two branches; the one *ascending*, which encircles the origin of the glutæus minimus, like the corresponding branch of the gluteal artery, and the other *descending*, which passes obliquely downwards and outwards, between the glutæus medius and minimus, to which it gives off numerous filaments, and thus, gradually diminished in size, it embraces, as it were, the posterior surface of the glutæus minimus, and having reached the external border of that muscle, it passes downwards, and enters the sheath of the tensor vaginæ femoris, in which it terminates. Before entering the sheath of the tensor vaginæ it gives off a remarkable branch, which turns round the anterior border of the glutæus minimus, and ramifies in that muscle.

The Nerve for the Pyriformis.

This little nerve arises separately from the posterior surface of the sacral plexus, and more particularly from the third sacral nerve; it divides into two branches, which immediately enter the anterior surface of the muscle.

The Inferior Gluteal Nerve.

The *inferior gluteal nerve* (*Bichat*), or the *lesser sciatic nerve* (*Boyer*), is intended for the glutæus maximus, the integuments of the posterior region of the thigh, and for a part of the skin of the leg. It arises from the back of the sacral plexus, sometimes by one cord, sometimes by several very distinct cords. It emerges from the pelvis (near *c*, *fig.* 293.), below the pyriformis, together with and on the inner side of the great sciatic nerve, to which it may be regarded as an accessory; it passes behind that nerve, and divides into two sets of branches, viz. *muscular* and *cutaneous*.

The *muscular branches* (*c*) are numerous, although exclusively intended for the glutæus maximus; they divide into *ascending* and *external* branches, which run along the anterior surface of the muscle, spread out upon it, and may be traced as far as its upper border, and *descending* and *internal* branches, which pass between the tuberosity of the ischium and the muscle, and then enter the latter.

The *cutaneous branch* (*b*) continues in the original course of the nerve, behind the great sciatic, and in front of the glutæus maximus; it crosses obliquely, downwards and inwards, over the tuberosity of the ischium and the origins of the biceps and semi-tendinosus muscles: considerably reduced in

size, from having given off several branches, it assumes the name of lesser sciatic (*f*), runs vertically downwards, becoming smaller and smaller, and may be traced down to the posterior region of the leg.

The cutaneous branch, as it emerges from the glutæus maximus, gives off a considerable *recurrent branch* (*e*), which might be regarded as a terminal branch of the nerve. This branch is reflected upwards so as to describe a curve having its concavity turned upwards, and subdivides into two secondary branches, an internal and an external: the *external branch* is the larger, and ramifies in the skin of the gluteal region; the *internal* or *scrotal branch* (pudendalis longus inferior, *Soemmerring*) is a very remarkable one; it is reflected forwards upon the under surface of the tuberosity of the ischium, runs along at some distance from the ascending ramus of the ischium and the descending ramus of the os pubis, anastomoses with the superficial perineal nerve, reaches the scrotum above the testis, and divides into two branches — an external, which passes on the outer side, and an internal, which runs on the inner side of the testis; having embraced this organ, they are distributed to the skin of the anterior part of the scrotum and the lower part of the penis. In the female, this branch belongs to the labia majora.

All along the thigh, the cutaneous branch of the inferior gluteal nerve gives off some very small external branches, and some larger internal branches which are reflected forwards, describing curves having the concavity turned upwards, and supply the skin of the internal region of the thigh.

In the popliteal space, the cutaneous branch divides into two filaments, one subcutaneous, which may be traced, notwithstanding its extreme tenuity, as far as the middle of the posterior region of the leg; and the other subaponeurotic, which perforates the fascia of the leg, runs along the external saphenous vein, and anastomoses with the external saphenous nerve.

The Nerves for the Quadratus Femoris and the Gemelli.

The *superior gemellus* receives a special nerve from the anterior part of the sacral plexus. The nerve for the *inferior gemellus* is a branch of the nerve for the quadratus femoris.

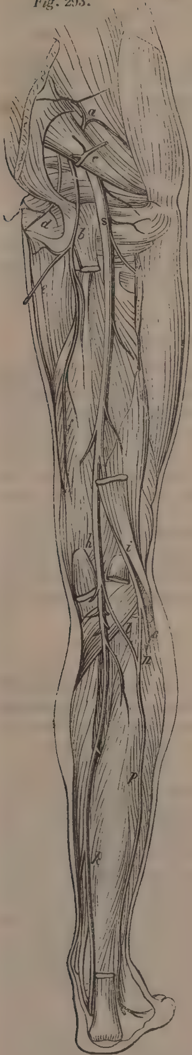
The *nerve for the quadratus femoris* is remarkable. It arises from the front of the sacral plexus, or rather from the limit between this plexus and the great sciatic nerve, passes vertically downwards in front of the gemelli and obturator internus, by which it is separated from the great sciatic nerve, and it is placed in contact with the os innominatum to the outer side of the tuberosity of the ischium. It gives off some *external periosteal and osseous* branches, which enter the foramina in the tuberosity of the ischium; some *internal* or *articular* branches, which perforate the fibrous capsule of the hip-joint; a branch for the inferior gemellus; and then terminates in the quadratus femoris, which it enters by its anterior surface.

The Terminal Branch of the Sacral Plexus, or the Great Sciatic Nerve.

The *great sciatic nerve* (grand fémoro-poplité, *Chauss.*) is intended for the muscles of the posterior region of the thigh, and for the muscles and integuments of the leg and foot: it is the termination (*s*, *fig.* 290.) of the sacral plexus, or rather it is the sacral plexus itself condensed into a nervous cord. The fifth lumbar nerve, a branch of the fourth lumbar, the three superior sacral nerves, and a branch from the fourth, form the origins of this great nerve, which is the largest in the body.

It emerges from the pelvis, through the great sciatic notch, below the pyriformis, immediately above the spine of the ischium, passes vertically downwards (*s*, *fig.* 293.) between the tuberosity of the ischium and the great trochanter, both of which project so as to separate it from the skin, or, more exactly, it runs along the outer side of the tuberosity of the ischium, in a very

Fig. 293.



deep groove between that process and the margin of the cotyloid cavity. At its exit from the pelvis, it is a flat ribbon-shaped nerve, six lines in breadth, but it soon becomes rounded, runs vertically downwards along the back of the thigh, sloping, however, a little outwards; having arrived about three or four fingers' breadth above the knee-joint, it divides into two branches, which are called the *external popliteal sciatic* or the *peroneal nerve* (*i*), and the *internal popliteal sciatic* or *tibial nerve* (*h*).

The sciatic nerve sometimes divides at its exit from the pelvis, but it may do so at any other point between that and the popliteal space. This premature division is of no importance; in fact it always exists; for when there is apparently only one trunk, the two branches of the bifurcation are perfectly distinct through the whole length of the thigh, and are merely in contact with each other.*

Relations. Behind, the great sciatic nerve is covered by the glutæus maximus, and then by the long head of the biceps and the semi-tendinosus; lower down it occupies the cellular interval between these two last-named muscles, and when they separate from each other to form the borders of the popliteal space, it becomes sub-aponeurotic.

In *front*, it corresponds to the gemelli and obturator internus, by which it is separated from the os coxæ, to the quadratus femoris and to the adductor magnus. During its course, it is surrounded by a large quantity of adipose cellular tissue, but has no accompanying vessel.†

Collateral branches of the great sciatic. The great sciatic nerve gives off in the thigh five muscular and three articular branches; they sometimes arise separately, sometimes by a common trunk. They are the following:—

The *nerve for the long head of the biceps*, which divides into two *ascending branches* for the origin of that muscle from the ischium, and *deccending branches*, which run for a long time in front of the muscle and then enter it by a series of filaments.

The *nerve for the semi-tendinosus*, which runs upon the anterior surface of the muscle, and does not enter it, until it reaches the lower third of the thigh.

The *nerves for the semi-membranosus* are two in number; they almost always anastomose and enter the internal surface of the muscle at two different points.

A *nerve for the adductor magnus*, which runs forwards and then inwards, and enters near the inner border of the muscle. We have seen that the adductor

* When the great sciatic nerve divides within the pelvis, the upper division perforates the pyriformis, while the lower emerges from below that muscle.

† In three instances I have found the great sciatic accompanied by a large vein, which was continuous with the popliteal vein, and perforated the upper part of the adductor magnus, like the profunda artery. In two of these cases the sciatic nerve divided at its exit from the pelvis. I did not note the arrangement of the nerve in the third case. It was a remarkable circumstance that there was another popliteal vein accompanying the artery; in one of the cases the vein was in front instead of behind the artery.

magnus receives most of its nerves from the obturator nerve. All the preceding branches arise from the upper part of the sciatic nerve, opposite to the quadratus femoris, and often by a common trunk.

A *nerve for the short head of the biceps* sometimes arises at the same height as the preceding, but is most commonly given off from the sciatic nerve at the middle of the thigh. When the sciatic nerve divides prematurely, the branch we are now describing comes from the external popliteal. This nerve enters the upper extremity of the muscle, expanding into diverging filaments.

An *articular nerve of the knee*, which often arises by a common trunk with the preceding, and is not unfrequently given off from the external popliteal ; it passes vertically downwards in front of the great sciatic nerve, through some adipose tissue, to gain the outer side of the joint; having arrived above the external condyle, it turns and divides into several filaments, which perforate the fibrous tissue of the joint, and are distributed to the articular adipose tissue, where they are scattered, some above, others below, and others on the outer side of the patella.*

The External Popliteal Sciatic or Peroneal Nerve.

The *external popliteal sciatic*, *external popliteal*, or *peroneal nerve* (*i*, *fig.* 293.), the external terminal branch of the great sciatic, is intended for all the muscles of the anterior and external region of the leg, and for the skin on the leg and on the dorsum of the foot. It is scarcely half the size of the internal popliteal; it runs obliquely downwards and outwards, behind the external condyle of the femur through the popliteal space, and is placed nearer to the surface than the internal popliteal nerve, which is lodged in the intercondyloid fossa; it then crosses obliquely over the origin of the outer head of the gastrocnemius, passes behind the head of the fibula, from which it is separated by the origin of the soleus, turns horizontally upon the neck of that bone (at *v*), between it and the peroneus longus, and expands into four branches, two superior or recurrent for the tibialis anticus, and two inferior and larger, which form the true terminations of the nerve.

Collateral Branches.

During this course, the external popliteal nerve gives off two superficial collateral nerves: a *saphenous nerve*, which we shall call the *peroneal saphenous* to distinguish it from the tibial saphenous, and the *peroneal cutaneous branch.*

The Peroneal Saphenous Nerve.

The *peroneal saphenous nerve* (*n*) presents many varieties in different subjects, both in regard to its size and origin. It is generally smaller than the tibial saphenous (*l*), of which it may be regarded as an accessory; it arises in the popliteal space, descends vertically beneath the fascia, between the external and internal popliteal nerves, perforates the fascia, opposite to the middle of the leg, to join the external saphenous vein, with which it runs along the tendo Achillis, and terminates upon the outer side of the os calcis. During this course, it gives off several cutaneous filaments and a communicating branch to the tibial saphenous nerve: this branch is of considerable size, and comes off whilst the nerve is still beneath the fascia. Having become very slender after giving these branches, the peroneal saphenous nerve subdivides, opposite to the lower part of the tendo Achillis, and upon the outer side of the os calcis, into several *calcaneal branches*, one of which turns obliquely round the posterior surface of the os calcis, whilst the others descend vertically, are reflected upon the under surface of that bone, and are distributed to the skin of the heel. Not unfrequently the peroneal saphenous nerve gives off a *malleolar branch*, which passes between the external malleolus and the skin, and anastomoses in front

* See note, p. 1088.

of the ankle joint (*y*, *fig.* 291.) with a twig from the musculo-cutaneous nerve. This malleolar branch, which often comes from the last-mentioned nerve, is moreover remarkable, like all nerves which are subjected to strong pressure, for its thickness, its greyish colour, and lastly for its knotted, and as it were ganglionated, appearance.

The peroneal saphenous nerve is often very small and is lost in the skin upon the middle of the leg: its place is then supplied in the lower two-thirds of the leg by the tibial saphenous nerve, the size of which is always in an inverse ratio to that of the peroneal saphenous.

No nerve presents more varieties than the peroneal saphenous; they relate to its size and to the point at which it anastomoses with the tibial saphenous. One of the most remarkable varieties is that in which the peroneal and tibial saphenous nerves, those called *communicating saphenous branches* (*communicans fibulæ, n; communicans tibiæ, l*) unite in the popliteal space into a single trunk, the *external saphenous* (*p*), the distribution of which corresponds to the ordinary distribution of the two nerves.

The Peroneal Cutaneous Branch.

This comes off from the external popliteal nerve, behind the outer condyle of the femur, passes vertically downwards along the fibula, in contact with the skin, and divides into ascending and descending branches, the latter of which may be traced as far as the lower part of the leg.

The Terminal Branches of the External Popliteal Nerve.

The Branches for the Tibialis Anticus.

The two *superior* or *recurrent branches*, resulting from the subdivision of the external popliteal, pass horizontally inwards, behind the extensor communis digitorum, and are distributed to the tibialis anticus; one of these branches supplies the peroneo-tibial articulation.

The Musculo-cutaneous Branch or External Peroneal Nerve.

The *musculo-cutaneous branch* (*x*, *fig.* 291.), the lowest of the terminal branches of the external popliteal, is intended for the muscles of the external region of the leg and for the skin upon the dorsum of the foot (prétibio-digital, *Chauss.*; peroneus externus, *Soemm.*).

It passes at first obliquely, then vertically, downwards in the substance of the peroneus longus, turns forwards to enter between the extensor longus digitorum and the peroneus longus and brevis, and perforates the fascia of the leg, above the ankle joint: having thus become subcutaneous, it passes obliquely downwards and inwards, following the direction of the extensor longus digitorum, becomes flattened and widened, and divides a little below the tibio-tarsal articulation into an internal and an external branch; the latter subdivides into three other branches, so that there are in all four terminal branches, which form the dorsal collateral nerves of the toes.

Not unfrequently the musculo-cutaneous nerve bifurcates as it escapes from beneath the fascia of the leg and its two branches re-unite opposite to the tibio-tarsal articulation, so as to describe an elongated ellipse.

Collateral branches. There are two *branches for the peroneus longus*, of which one comes off from the nerve immediately after its origin, whilst the other arises lower down and runs a very long course in the substance of the muscle; there is also a branch *for the peroneus brevis*, which often arises by a common trunk with the preceding.

In its subcutaneous portion, the musculo-cutaneous nerve supplies several filaments to the skin, among which we should distinguish an *external malleolar filament*, which passes between the external malleolus and the skin, increases considerably in size and becomes greyish and knotted, like all nerves subjected

to pressure. This filament often anastomoses with the malleolar branch of the peroneal saphenous nerve, and sometimes supplies the place of that malleolar branch.

Terminal branches. There are four terminal branches of the musculo-cutaneous nerve, distinguished numerically as the first, second, third, and fourth (see *fig.* 291.). The *first* or *internal* branch passes very obliquely forwards and inwards, to form the *internal dorsal collateral nerve* of the great toe; this nerve, like all nerves subjected to pressure, increases in size and becomes greyish and as it were knotted opposite the metatarso-phalangal articulation. The *second* branch, which often arises by a common trunk with the first, supplies the *external dorsal collateral nerve* of the great toe and the *internal collateral nerve* of the second toe. The *third* branch supplies the *external collateral nerve* of the second and the *internal collateral nerve* of the third toe. These two large branches are often replaced by one (*v*) from the anterior tibial nerve, with which they anastomose. The fourth terminal branch or *internal branch* supplies the *external dorsal collateral* nerve of the third and the *internal dorsal collateral* nerve of the fourth toe.

All the filaments from these branches are distributed to the skin upon the dorsal region of the foot and digital phalanges.

In a great number of subjects, the tibial or external saphenous nerve supplies the internal collateral nerve of the little toe, and the external collateral nerve of the fourth toe: but in others, these nerves are furnished by an additional terminal branch of the musculo-cutaneous nerve; in all cases, the nerves anastomose with each other.

The Anterior Tibial or Interosseous Nerve.

The *anterior tibial* or *interosseous nerve* (*v v*, *fig.* 291.), intended for the muscles on the anterior region of the leg, for the extensor brevis digitorum, and for the interosseous muscles in the foot, is as large as the musculo-cutaneous nerve just described; it runs to the inner side of that nerve, beneath the extensor communis digitorum, and passes along the interosseous ligament, together with the anterior tibial artery, lying in front of that vessel. It is placed, like the artery, between the tibialis anticus and the extensor communis digitorum, from which it is separated below by the extensor proprius pollicis pedis; it supplies a great number of filaments to all these muscles, passes with the artery under the annular ligament of the tarsus, in the sheath of the extensor proprius pollicis, and divides into two branches: —

The *internal deep branch of the dorsum of the foot* (*v*), which is the true continuation of the nerve, passes horizontally forwards, under the arteria dorsalis pedis, over the first interosseous space, gives off a small twig to the muscles of that space, and divides into two branches, which form the *deep external dorsal collateral nerve* of the great toe and the *internal dorsal collateral nerve* of the second toe. These branches communicate with the superficial dorsal branches of the musculo-cutaneous nerve, and sometimes supply their place.

The *external* and *deep nerve of the dorsum of the foot* runs outwards between the tarsus and the extensor brevis digitorum, in which it terminates; it gives off in front, opposite the interosseous spaces, a series of very delicate filaments, which enter the posterior extremities of those spaces. The filaments for the fourth and fifth spaces often arise by a common trunk. They are extremely delicate, and are closely applied to the tarsus.

The Internal Popliteal Sciatic or Tibial Nerve.

The *internal popliteal sciatic*, *internal popliteal*, or *tibial nerve* (*h*, *fig.* 293.), is intended for all the muscles of the back of the leg, and for the skin of the sole of the foot; both in direction and size, it appears to be the continuation of the great sciatic nerve. It passes vertically downwards in the inter-condyloid fossa of the femur; it is at first placed between the heads of the gastro-

cnemius, it then passes under that muscle and under the arch formed by the soleus, descends, under the name of the *posterior tibial* nerve (*k*), between the soleus and the deep layer of muscles, inclines a little inwards, and, having reached the termination of the fleshy belly of the soleus, gains the inner side of the tendo Achillis; lower down, it passes behind the internal malleolus, against which it is flattened and widened, and divides into the *internal* and *external plantar nerves* (*a*, *b*, and *c*, *fig.* 294.).

In the popliteal space it is sub-aponeurotic, in the fleshy portion of the leg it is separated from the fascia by the double layer formed by the gastrocnemius and the soleus, and it again becomes sub-aponeurotic along the tendo Achillis. It is in relation, in front, with the popliteal and posterior tibial vessels, which separate it, above, from the knee-joint and popliteus muscle, and lower down, from the deep layer of muscles in the leg.* Behind the internal malleolus, and under the groove upon the os calcis, it is inclosed in a common fibrous sheath with the posterior tibial vessels, which are placed in front of it; this sheath is behind that for the tendons of the tibialis posticus and flexor communis digitorum.

Its *collateral branches* are very numerous. I shall divide them into those given off opposite the knee-joint, and those supplied along the leg.

The Collateral Branches of the Internal Popliteal Nerve, behind the Knee-Joint.

These are six in number, namely, two anterior, which are very small, one for the plantaris longus, and one for the knee-joint; two internal, namely, the tibial saphenous nerve, and the nerve for the inner head of the gastrocnemius; two external, namely, the nerve for the outer head of the gastrocnemius, and the nerve for the soleus.

The Tibial Saphenous Nerve.

This is generally known as the *external saphenous.* It is much larger than the peroneal saphenous, which always anastomoses with it. I have already said that the mode and situation of this anastomosis present many varieties. The tibial saphenous nerve (*communicans tibiæ*, *l*, *fig.* 293.) arises in the popliteal space, passes vertically downwards between the two heads of the gastrocnemius, and then upon their posterior surface, along their fibrous septum between them; it is here situated in a small fibrous canal common to it and to a small artery and vein; it receives, at a variable height in the leg, a more or less considerable filament from the peroneal saphenous nerve (or *communicans fibulæ*, *n*); it then becomes subcutaneous, forming the external saphenous nerve (*p*), runs along the outer side of the tendo Achillis, just as the posterior tibial runs along its inner side; it now accompanies the external saphenous vein, which is accompanied above this point by the peroneal saphenous nerve; it is reflected behind the external malleolus, in the same manner as the tibial nerve is reflected upon the internal malleolus, then runs forwards and downwards (*y*, *fig.* 291.), upon the outer side of the os calcis, where it gives off several very large *external calcaneal nerves*, and terminates differently in various subjects. In some it terminates by forming the dorsal collateral nerve of the fifth toe; in others it is larger and divides into two branches, of which the external forms the external collateral nerve of the fifth toe, while the internal, which receives an anastomotic branch from the musculo-cutaneous nerve (*x*), passes horizontally forwards, crosses the extensor brevis digitorum, and the tendons of the long extensors, and divides into two secondary branches, of which one constitutes the internal dorsal collateral nerve of the little toe, and the other the external dorsal collateral nerve of the fourth toe. I may

* [The nerve is at first at a short distance to the outer side of the artery; lower down it lies immediately behind the vessel, and still lower crosses to the inner side of the artery, and is separated from it by the vein.]

point out the thickening, the grey colour, and the knotted, and as it were, gangionated structure of the external collateral nerve of the little toe opposite to the articulations.

The *external calcaneal nerves*, which may be regarded as forming the termination of the tibial saphenous, are very remarkable; they pass vertically along the outer side of the os calcis, expand into several filaments, which are reflected upon the ridge which separates the external from the inferior surface of that bone, and are distributed to the skin upon the heel.

During its course along the leg, the tibial saphenous gives off scarcely a single filament, but along the outer border of the foot, it supplies a great number, which run downwards and forwards, and terminate in the skin covering the external plantar region.

The size of the tibial saphenous nerve is inversely proportioned to that of the peroneal saphenous and musculo-cutaneous nerves. Thus, when the peroneal saphenous nerve is large, it furnishes most of the external calcaneal branches, and when the musculo-cutaneous nerve is large, it supplies, besides the external calcaneal, the internal dorsal collateral nerve of the little toe, and the external dorsal collateral nerve of the fourth toe.

The Nerves for the two Heads of the Gastrocnemius and for the Soleus.

The nerve for the inner head of the gastrocnemius often arises by a common trunk with the tibial saphenous; again, the nerves for the outer head of the gastrocnemius and for the soleus often arise by a common trunk: the nerves for the gastrocnemius enter the anterior surface of the head of that muscle and immediately ramify. The nerve for the soleus is the largest, and enters the muscle at its upper arch; all these nerves ramify as soon as they enter the muscles which they supply.

The Articular Nerve, and Nerve for the Plantaris Longus.

The *posterior articular nerve of the knee* runs forwards to enter the posterior ligament of the articulation: one of its filaments follows the direction of the internal articular artery, and is lost in the popliteus.*

The *nerve for the plantaris longus* always arises separately from the posterior tibial nerve, and immediately dips into the substance of the muscle.

Collateral Branches of the Internal Popliteal Nerve in the Leg.

There are three sets of collateral branches given off by the posterior tibial nerve in the leg: namely, the nerve for the popliteus; the nerves for the deep layer of muscles; the internal calcaneal nerve. Lastly, several very small filaments come off from the nerve, run along the posterior tibial artery, and, after a course of variable length, perforate the aponeurosis and ramify in the skin.

The *nerve for the popliteus* arises opposite the knee-joint, runs forwards on the outer side of the popliteal vessels, to gain the lower border of the muscle, around which it turns; before entering the muscle, the nerve expands into several branches, all of which pass horizontally forwards opposite to the inter-

* [From the dissections of Mr. Ellis, it appears that there is an articular nerve to the knee-joint with each articular artery. The *superior external articular* nerve is the one described at p. 1084.; it most commonly arises from the external popliteal. The *inferior external articular* also arises from the external popliteal, and sometimes from the sciatic nerve; it is a long branch which descends towards the external condyle, passes below it on the outer side of the joint, and perforates the capsule. The *superior internal articular* is very small, and is not constant; it arises from the internal popliteal nerve, and passes on the outer side, and then in front of (*i. e.* deeper than) the popliteal vessels, and reaches with its artery the inner side of the joint. The *inferior internal articular* is the largest of all; it arises from the internal popliteal above the joint, descends on the outer side, and then in front of the popliteal vessels, is applied to the corresponding artery upon the popliteus muscle, passes beneath the internal lateral ligament, and enters the inner side of the joint. The *posterior articular*, or *azygos*, is given off opposite the joint from the internal popliteal, or from the inferior internal articular; it perforates the posterior ligament. (*Ellis's Demonstrations of Anatomy*, pp. 675, 676.)]

osseous ligament, which they appear to perforate. But with a little care it is seen that almost all of these filaments are lost in the muscle. I have, however, seen one of them perforate the interosseous ligament together with the anterior tibial artery, and then, leaving that vessel, return through the substance of the ligament, and terminate in the tibialis posticus; several filaments of the popliteal nerve are also evidently distributed to the peroneo-tibial articulation, and to the periosteum of the tibia and fibula.

The nerves for the deep layer of muscles of the leg consist of two sets. The *nerve for the tibialis posticus* almost always arises by a common trunk with the preceding, runs downwards and forwards, is applied to the posterior surface of the muscle, to which it gives a series of filaments from its anterior aspect; the continuation of the nerve enters the muscle about its middle, and may be traced in it as far as its lower part. The *nerves for the flexor longus pollicis* and for the *flexor communis* arise by a common trunk a little below the preceding: the nerve for the flexor longus pollicis, which is larger than those for the flexor communis and tibialis posticus, accompanies the peroneal artery as far as the lower part of the leg.

The internal calcaneal nerve. This is a large branch which comes off from the inner side of the posterior tibial nerve, and which, in cases of premature bifurcation of that nerve into the internal and external plantar, comes from the external plantar; it passes vertically downwards, on the inner side of the os calcis, and divides into two diverging branches, which are applied to the inner side of the bone, are reflected upon its lower surface, and are distributed to the skin of the heel, one in front, and the other behind.

The Terminal Branches of the Internal Popliteal Nerve.

The Internal Plantar Nerve.

The *internal plantar nerve*, which is intended for the muscles and skin of the sole of the foot, is larger than the external plantar; at its origin it is situated behind the internal malleolus, in front of the posterior tibial vessels, which cross it at an acute angle, and occupies a groove which is common to it and to those vessels, and which is quite distinct from and lies behind the groove for the tendons. It is reflected beneath the internal malleolus, becomes horizontal, reaches the calcaneal groove, perforates the posterior extremity of the flexor brevis digitorum, and during this passage through the groove is protected by a fibrous canal, which is subjacent to the grooves for the tendons.

Fig. 294.

At its exit from this fibrous canal, the internal plantar nerve is situated upon the boundary, between the internal and middle plantar regions, between the flexor brevis pollicis on the inside, and the flexor brevis digitorum on the outside; having given off a considerable branch (*a*, *fig.* 294.), which becomes the *internal plantar collateral nerve of the great toe*, it perforates the aponeurosis of the flexor brevis digitorum to enter the same sheath as that muscle, and runs (*b*) along its inner border. Having reached the posterior extremity of the metatarsal bones, it divides into three branches which form the collateral nerves of the toes. Sometimes there is a fourth branch (*d*), which passes outwards, to anastomose with the external plantar nerve.

The *collateral branches* are very numerous. Some of them are *cutaneous*, and perforate the plantar fascia to ramify in the skin. The most remarkable are, a small *calcaneal cutaneous nerve*, which crosses the posterior tibial vessels, to supply the skin upon the inner side of the os calcis; and

a *plantar cutaneous nerve*, which emerges between the flexor brevis pollicis and the flexor brevis digitorum, and divides into two small cutaneous branches, one of which proceeds forwards, whilst the other runs backwards, like a recurrent nerve. There are also some *muscular collateral branches*, namely, *for the flexor brevis pollicis*, the *abductor pollicis*, and *the flexor brevis digitorum.* Lastly, the *internal plantar collateral nerve of the great toe* (*a*), which is so large that it might be regarded as a terminal branch of the internal plantar nerve; it comes off from the last-named nerve, at its exit from the covered canal formed for it by the flexor brevis pollicis, passes forwards along the outer side of the tendon of the flexor longus pollicis, below, *i. e.* superficial to the inner portion of the adductor pollicis (oblique adducteur, *Cruveilhier*), and gains the inner and under surface of the metatarso-phalangal articulation of the great toe; in this place it is situated in the furrow between the internal and external sesamoid bones of that articulation; it runs forwards below the inner border of the former, and then of the second phalanx of the great toe, and, having arrived below that bone, it divides, like the collateral nerves of the fingers, into two branches, the one *dorsal* or *ungual*, and the other *plantar.*

The *terminal branches of the internal plantar nerve* are three in number, and are distinguished as the first, second, and third, counting from within outwards.

The *first terminal branch*, which is the largest, runs along the outer side of the tendon of the flexor longus pollicis, gives filaments to that muscle, passes between the metatarso-phalangal articulations of the first and second toes, under an arch which is common to it and the corresponding vessels, and divides into two secondary branches, which form the *external collateral nerve of the great toe*, and the *internal collateral nerve of the second toe.* Not unfrequently this branch gives an anastomotic filament to the internal collateral nerve of the great toe, which passes beneath the metatarso-phalangal articulation of that toe.

The first terminal branch of the internal plantar nerve gives off the *filament for the first lumbricalis;* it then supplies several *articular twigs* to the metatarso-phalangal articulation of the great toe, and a very numerous series of *cutaneous* filaments.

The *second terminal branch*, much smaller than the preceding, passes somewhat outwards, crossing below, *i. e.* superficial to the flexor tendon of the second toe, and then forwards, and bifurcates opposite the metatarso-phalangal articulations, to constitute the *external plantar collateral nerve* of the second toe, and the *internal plantar collateral nerve* of the third.

During its course, this branch supplies filaments to the *second lumbricalis*, to the metatarso-phalangal articulation of the second toe, and also to the integuments.

The third terminal branch passes very obliquely outwards, crosses below the flexor tendon of the third toe, and bifurcates to form the *external collateral nerve of the third* and the *internal collateral nerve of the fourth toe.*

This branch supplies the metatarso-phalangal articulations of the third and fourth toes, and the corresponding integuments.

Summary. The internal plantar nerve, therefore, supplies branches to the skin on the inner part of the sole of the foot, also the plantar collateral nerves of the first, second, and third toes, and the internal collateral nerve of the fourth toe, all of which are cutaneous branches.

It gives *muscular branches* to the flexor brevis pollicis, the abductor pollicis, the flexor brevis digitorum, and to the two internal lumbricales.

Lastly, it gives off a great number of *articular filaments* to the tarsal, tarso-metatarsal, metatarso-phalangal, and phalangal articulations.

The External Plantar Nerve.

The *external plantar nerve* (*c*, *fig.* 294), which is smaller than the internal, is placed with it in the groove of the os calcis, and perforates the flexor brevis,

under an arch distinct from that for the internal plantar, and which is common to it and the external plantar vessels; it then runs downwards and outwards, between the flexor brevis and flexor accessorius, is reflected forward, and divides into two branches, a *superficial* and a *deep*.

Collateral branches. During its course, the external plantar nerve gives off, immediately after its origin, one large branch, which runs horizontally outwards, in front of the tuberosities of the os calcis, passes under the flexor accessorius, and is reflected forwards to enter the *abductor minimi digiti*. At the point of its reflection, it gives off a transverse branch, which is lost in the posterior attachment of the muscle. The external plantar also supplies the nerve or *nerves for the flexor accessorius*.

Terminal branches. The *superficial terminal branch* (*c*, *fig.* 294.), which is the continuation of the trunk of the nerve, divides into two others, one external, the other internal.

The *external branch* passes very obliquely outwards, below the flexor brevis digiti minimi, crosses the tendon of the abductor brevis obliquely, then runs along the outer side of the fifth metatarso-phalangal articulation, and forms the *external collateral nerve of the little toe*. It supplies a great number of cutaneous nerves, also the nerves for the *flexor brevis digiti minimi*, those for the *interosseous muscles* of the fourth space, and lastly, some *articular filaments*.

The *internal branch* passes forwards, below the flexor tendon, following the original direction of the superficial branch of the external plantar, and, after a rather long course, bifurcates to form the *internal collateral nerve of the little toe*, and the *external collateral nerve of the fourth toe*; like the external branch, it also gives off some cutaneous and articular nerves.

The *deep terminal branch* of the external plantar passes above, *i. e.* deeper than the flexor accessorius, changes its direction, so as to describe an arch, having its concavity turned inwards and backwards, and the convexity outwards and forwards, enters, together with the external plantar artery, above which it is situated, between the adductor pollicis and the interossei, and is lost in the former muscle.

Before reaching the adductor pollicis it gives off some *articular filaments* to the metatarsal and tarso-metatarsal articulations, and also a filament for the fourth lumbricalis. Beyond the adductor pollicis the nerve gives off the *filament for the third lumbricalis*; this filament, which is remarkable for the length of its course, passes horizontally forwards, opposite to the third interosseous space, and passes through the fibres of the transversus pedis, to reach its destination; it then gives off the *filaments for the transversus*, and those for the *interosseous muscles of the third, second, and first, spaces*.

Summary of the external plantar nerve. The external plantar nerve, therefore, supplies *cutaneous filaments* to the outer side of the sole of the foot, to the fifth toe, of which it forms both collateral nerves, and to the fourth toe, of which it forms the external collateral nerve. It also gives off *muscular nerves* to the flexor accessorius, the flexor brevis, and abductor digiti minimi, to the adductor pollicis, and transversus pedis, to all the interossei, and to the two external lumbricales. Lastly, it furnishes some *articular filaments*.

Summary of the nerves of the lower extremity. The lower extremity is supplied with nerves from the lumbar and sacral plexuses.

The lumbar plexus. The lumbar plexus gives almost all its branches to the lower extremity, viz. the external and internal inguinal nerves, the obturator nerve, and the crural nerve; the lumbo-sacral cord is also distributed to the lower extremity through the medium of the sacral plexus.

The external and internal inguinal nerves are the principal cutaneous nerves of the anterior and external regions of the thigh; the obturator nerve is a muscular nerve intended for the obturator externus, the three adductors, and the gracilis.*

* [The obturator also supplies part of the pectineus, and sometimes gives cutaneous branches to the thigh and leg, and an articular filament to the knee (see note, p. 1072.).]

The crural nerve is a musculo-cutaneous nerve which supplies the following parts: — its cutaneous portion is distributed to the skin upon the anterior region of the thigh, upon the internal region of the leg, and internal dorsal region of the foot; its muscular portion supplies all the muscles of the anterior region of the thigh *; it also gives several articular nerves to the hip and knee-joints.

The sacral plexus. The sacral plexus is entirely distributed to the lower extremity, excepting the internal pudic nerve and certain rectal and vesico-prostatic branches in the male, and rectal, vaginal, and uterine branches in the female.

The obturator internus, the pyriformis, the gemelli, and the quadratus femoris, are each provided with a special nerve from the sacral plexus; the glutæus medius and minimus, and the tensor vaginæ femoris, are especially supplied by the superior gluteal nerve, and the glutæus maximus by the inferior gluteal or lesser sciatic nerve. The last-named nerve also furnishes the cutaneous nerves of the posterior region of the thigh.

The great sciatic is the nerve of the posterior region of the thigh, and of the entire leg and foot. It supplies all the muscles of the posterior region of the thigh; thus its *external popliteal* or *peroneal division* supplies the muscles of the external region of the leg, by its musculo-cutaneous branch, and the muscles of the anterior region by its interosseous branch; it also supplies the external region of the leg, and the dorsal region of the foot.

Its *internal popliteal or tibial division* supplies all the muscles of the posterior region of the leg, the skin upon the internal and external calcaneal regions, and that upon the external dorsal region of the foot.

Of its terminal branches, the *internal plantar nerve* is distributed to the muscles of the internal plantar region of the foot, to the flexor brevis digitorum, to the two internal lumbricales, and to the skin of the internal plantar region; lastly, it gives off the collateral branches of the toes, excepting the two for the fifth toe, and the external collateral branch of the fourth.

The *external plantar nerve* is distributed to the muscles of the external plantar region, to the flexor accessorius, to all the interossei, to the two external lumbricales, to the adductor pollicis and transversus pedis, and to the skin of the external plantar region: it also gives the internal and external collateral nerves of the fifth toe, and the external collateral nerve of the fourth.

Comparison of the Nerves of the Upper and Lower Extremities.

The lumbo-sacral plexus, which supplies the whole of the lower extremity, precisely corresponds to the cervico-brachial, which supplies the upper extremity. The lumbar corresponds to the cervical, and the sacral to the brachial plexus. The connexion, or sort of fusion of the cervical with the brachial plexus, and of the lumbar with the sacral plexus, explains why it is found, on comparing the nerves of the upper and lower extremity, that several of the nerves arising from the brachial plexus are represented by nerves from the sacral plexus, and that several of those from the cervical plexus have their representatives in nerves derived from the lumbar plexus. It will be seen, moreover, that this analogy ought not to be carried too far, and that it is necessary, in making the comparison, to exclude all nerves which belong to peculiar organs in both regions. Thus, the phrenic, occipital, and auricular nerves, branches of the cervical plexus, have no representatives in the lower extremity, nor is there any nerve in the upper extremity corresponding to the internal pudic.

On the other hand, there is no objection to admitting that the external and internal inguinal nerves in the lower extremity are represented by the clavicular nerves in the upper extremity.

* [And also a few filaments to the iliacus, psoas, and pectineus.]

The crural nerve, a branch of the lumbar plexus, has no corresponding branch in those of the cervical plexus, but its muscular branches are represented by the brachial portion of the musculo-spiral nerve, and its cutaneous branches by the internal brachial cutaneous. The crural nerve, in fact, supplies the muscles which extend the leg upon the thigh, in the same way that the musculo-spiral nerve supplies the muscles which extend the fore-arm upon the arm; the internal saphenous nerve supplies the skin of the leg, just as the internal brachial cutaneous is distributed to the skin of the fore-arm.

The obturator nerve, which supplies the adductors of the thigh, is represented by the thoracic nerves and the nerve for the latissimus dorsi, which supply the pectoralis major and latissimus dorsi, the adductor muscles of the arm.

The gluteal nerves are analogous to the supra-scapular and circumflex nerves. The superior gluteal, which is distributed to the glutæus medius and minimus, corresponds to the supra-scapular, which belongs to the supra- and infra-spinatus; and the inferior gluteal or lesser sciatic nerve, which supplies the glutæus maximus and the skin of the thigh, corresponds to the circumflex nerve, which is distributed to the deltoid, and the skin of the arm.

The trunk of the great sciatic nerve represents by itself the musculo-cutaneous, the ulnar, and the median nerves, and the musculo-spiral in the fore-arm.

The muscles of the anterior region of the arm, that is to say, the muscles that flex the fore-arm upon the arm, receive their branches from the musculo-cutaneous nerve, just as the muscles of the posterior region of the thigh or the flexors of the leg upon the thigh receive theirs from the great sciatic.

The external popliteal nerve represents the musculo-spiral in the fore-arm: the former supplies the muscles of the anterior and external regions of the leg, whilst the latter is distributed to the muscles of the posterior and external regions of the fore-arm; the former gives off the dorsal cutaneous nerves of the foot, and the latter furnishes the dorsal cutaneous nerves of the hand.

The internal popliteal nerve represents the median and ulnar nerves together. The muscles of the posterior region of the leg are supplied by the internal popliteal, as the muscles of the anterior region of the fore-arm are supplied by the median and the ulnar.

The internal popliteal nerve completes the series of dorsal cutaneous nerves of the foot, just as the ulnar nerve completes the dorsal nerves of the hand.

Lastly, the internal plantar nerve gives off all the plantar collateral nerves of the toes, excepting those for the little toe, and the external plantar collateral of the fourth toe; it therefore represents the palmar portion of the median nerve; and so the external plantar represents the palmar portion of the ulnar nerve, and completes the series of plantar collateral nerves.

THE CRANIAL NERVES.

Definition and classification.—The Central Extremities of the Cranial Nerves—viz. of the olfactory—of the optic—of the common motor oculi—of the pathetic—of the trigeminal—of the external motor oculi—of the portio dura and portio mollis of the seventh—of the glosso-pharyngeal, pneumo-gastric, and spinal accessory divisions of the eighth—and of the ninth nerves.

THE *cranial nerves* are those which pass through the foramina in the base of the cranium, not those which arise from the brain, as the rather generally adopted terms *cerebral nerves* and *encephalic nerves* would seem to indicate.

We shall follow Willis and the majority of anatomists in admitting nine pairs of cranial nerves, which are almost indifferently named, either numerically, from the order of their origin, counting from before backwards, or

they are named from their distribution and uses. The following exhibits their nomenclature upon both principles:

First pair, or olfactory nerves.
Second pair, or optic nerves.
Third pair, or common motor nerves of the eyes.
Fourth pair, or pathetic nerves, nervi trochleares.
Fifth pair, or trifacial nerves, nervi trigemini.
Sixth pair, or external motor nerves of the eyes, nervi abducentes.
Seventh pair, divided into { portio mollis, or auditory nerve, portio dura, or facial nerve.
Eighth pair, divided into { pneumogastric nerve, or par vagum, glosso-pharyngeal nerve, spinal accessory nerve of Willis.
Ninth pair, or hypoglossal nerve.

Soemmerring has introduced the following modification of this nomenclature. He has divided the seventh pair into two, viz. the facial nerves, which form his seventh pair, and the auditory nerves which he calls the eighth; and then he has divided the eighth pair into three others, namely, a ninth pair formed by the glosso-pharyngeal nerves, a tenth formed by the pneumogastric nerves, an eleventh by the spinal accessory nerves; the hypoglossal nerves, therefore, constitute his twelfth pair.

This modification is founded on the separation of nerves so completely distinct as the facial and the auditory, which have only been described together because they enter the same canal in the base of the cranium, namely, the internal auditory meatus.

Still this modification is a useless one, and it has the greater inconvenience of rendering the language employed obscure, from giving a double acceptation to the same terms.

It would be more philosophical to name and describe the cranial nerves from behind forwards, so that the hypoglossal nerves would constitute the first pair and the olfactory the last.

The indisputable analogy which exists between the posterior cranial and the spinal nerves, and, moreover, the example of J. F. Meckel would fully warrant this innovation. Nevertheless, I think it right to retain the old usage, and to proceed from before backwards, in the enumeration as well as in the description of the nerves.

As the origins or central extremities of all the cranial nerves and their course within the cranium can be studied upon the same brain, I have thought it right to describe in one article all these origins or central extremities, which will mutually illustrate each other by their differences and their analogies: the experience of the dissecting room proves moreover that, from want of a sufficient number of brains to study the origin of each nerve in particular, this part of anatomy is generally neglected.

The Central Extremities of the Cranial Nerves.

Dissection. Two preparations are required, namely, a brain removed from the cranium, together with the origins of the nerves perfectly preserved; and the base of a cranium, together with those parts of the brain which are near the origin of the nerves. The first will serve for the examination of the central extremities of the nerves; and the second for tracing their course within the cranium.

Whilst the origin of all the spinal nerves is uniform and regular, that of the cranial nerves appears to be subject to no rule; so that the cranial nerves differ as much from each other in regard to their origin as they differ collectively from the spinal nerves in the same particular. We shall see presently, however, that the origins of all but the special nerves of the head may, to a certain extent, be referred to the same law of double roots (one of which is ganglionic) which presides over the origin of the spinal nerves.

The Central Extremity of the Olfactory Nerve.

The *olfactory nerves* or the *first pair of cranial nerves* (nerfs ethmoidaux, *Chauss.*; 1. *fig.* 276.) are two bands, composed of white and grey substance, which arise from the hindermost convolution of the anterior lobe of the brain, run forwards in the anfractuosity already described as the *anfractuosity of the olfactory nerves*, and expand in the ethmoidal groove into a sort of ganglion or *bulb*, from which filaments are given off to be distributed to the pituitary membrane.

In regard to their central extremity and their course within the cavity of the cranium, the olfactory nerves are singular, and their peculiarities justify the uncertainty which has for a long time prevailed, and still prevails, concerning their true character. The old anatomists did not regard them as nerves, but as prolongations of the brain, named by them *carunculæ* or *processus maxillares*, and believed to be intended to drain off the mucosity of that organ: it was Massa, according to Sprengel, and Zerbi, according to Haller, who first connected them with the other cranial nerves as the first pair. Comparative anatomy, which probably suggested to the older anatomists the opinion which they held concerning these nerves, has now caused some doubts as to the propriety of considering them as nerves, and has given rise to the opinion that they are the representatives of the *olfactory lobes* of the lower animals.* Without entering here into discussions which belong to philosophical anatomy, let us examine the most remarkable circumstances connected with the origin and cranial course of this nerve.

Apparent origin. The olfactory nerves arise from the cerebrum, and this is a character which belongs exclusively to them; they are the only cerebral nerves, properly so called.

They arise from the hindermost convolution of the anterior lobe, in front of the anterior locus perforatus (*h, fig.* 276.), which is situated behind that convolution. This origin consists of a mamilla or pyramidal enlargement, *grey pyramid*, which is regarded as the *grey root* of the nerve. This greyish enlargement, which can be very well seen by reflecting the nerve backwards, is prolonged as a linear tract of grey substance upon the upper surface of the nerve.

Besides this grey enlargement or origin, which was so well described by Scarpa, there are two or three white roots, or rather certain white striæ, very accurately represented by Vicq d'Azyr; these are the *external* or *long root*, which is concealed in the fissure of Sylvius, and appears to me to arise from the posterior lobe [middle lobe] of the cerebrum, or more exactly from the posterior lip of the fissure of Sylvius; and the *internal* or *short root*, which arises from the innermost convolution of the anterior lobe and joins the long root at an acute angle; between these roots we often see one, two, or even three striæ which come from the back part of the anterior lobe. It would be both useless and tedious to describe all the varieties of this origin.

Real origin. Anatomists have not confined themselves to the investigation of the apparent origin of the olfactory nerves, but have also endeavoured to ascertain their deep or real origin. Willis described them as arising from the medulla oblongata, Ridley from the corpus callosum, Vieussens, Winslow, and Monro from the corpora striata.†

If, after the example of Scarpa, a transverse perpendicular section of the brain be made opposite the junction of the grey and white roots of the olfactory

* When speaking of the comparative anatomy of the brain, it was mentioned that in a great number of animals there existed, in front of the cerebral lobes or hemispheres, a pair of lobes (*olfactory lobes*), which were continuous with the nerves distributed to the pituitary membrane, and the development of which corresponded to the size of those nerves, and to the relative state of perfection of the sense of smell.

† Chaussier, who adopted the latter opinion, called the corpora striata the *olfactory lobes*, in contradistinction to the optic thalami, which he terms the optic lobes. But comparative anatomy shows that there is no relation in point of developement between the corpora striata and the olfactory nerves.

nerves, or if a stream of water be directed upon the pyramidal mamilla above described, or lastly, if Herbert Mayo's method be adopted, and the origin of this nerve be examined in a brain hardened in alcohol, it will be seen that, besides the white superficial striæ, there are a great number of deep and diverging white roots, which appear to me to come from the anterior commissure and not from the corpus striatum.*

It would follow, therefore, that the olfactory nerves arise by a commissure like the optic nerves.

Cranial course. Having arisen in this manner by a sort of bulb or grey enlargement (*enlargement or bulb of origin*), the olfactory nerve immediately tapers, and is received into the antero-posterior sulcus intended for it, which conducts it as far as the ethmoidal groove or fossa (1, *fig.* 296.), where it forms an enlargement or bulb, named the *ethmoidal bulb*, which is analogous in many respects to its bulb of origin.

When seen from below, the olfactory nerve has the appearance of a soft smooth band, grooved longitudinally along the middle. †

But on reflecting the nerve backwards, it is found to be prismatic and triangular, that its two lateral surfaces are concave and correspond to the convolutions which bound the antero-posterior sulcus for the nerve, and that its upper ridge is formed by a linear tract of grey matter which connects the grey substance of its bulb of origin with that of the ethmoidal bulb.

The arachnoid has a peculiar arrangement in relation to this nerve: instead of immediately forming a sheath for it, the arachnoid passes below it, and maintains it in contact with its protecting sulcus; whilst the pia mater passes above it, and lines the sulcus. The nerve is not entirely separated from the brain, until about a few lines from the ethmoidal bulb.

In the human subject the olfactory nerve is not hollow in its centre, as in the mammalia; when hardened by alcohol, it may be decomposed into white parallel fibres, exactly similar to the fibres of the white substance of the brain.

The ethmoidal bulb or enlargements. The olfactory nerves, converging towards each other, reach the ethmoidal fossæ, where each immediately expands into an olive-shaped, ash-coloured, and extremely soft bulb (the ethmoidal bulb, 1, *fig.* 276.), to which Malacarne first applied the term ganglion, and which is formed in the following manner: — the white filaments of which the olfactory band or prism is composed spread out like a palm branch as they are about to enter the bulb, and dip into the grey or ash-coloured substance, which occupies the intervals between them: this substance is precisely analogous to the grey matter of the brain, but is less consistent; it also resembles the substance of the nervous ganglia, so that Scarpa does not hesitate to regard the ethmoidal bulb as a ganglion. From this enlargement are given off the olfactory nerves properly so called, which seem as if they were pressed through the foramina of the cribriform plate of the ethmoid bone. It is said that the grey matter sends prolongations through these foramina, but this has not been demonstrated.

The Central Extremity of the Optic Nerve.

The *optic nerves*, or *second pair* (2, *fig.* 276.), present certain peculiarities in their texture, and in their cranial course, which distinguish them from all other nerves.

They have this peculiar character, that they arise by a commissure (the

* Scarpa says that the deep roots come from a white cord placed in front of and below the corpora striata. Herbert Mayo, in his beautiful plates, has represented these roots as coming from the corpora striata.

† Willis and Santorini have noticed this groove. Scarpa has observed three grooves, which he regards as corresponding to as many lines of grey substance. M. Hippolyte Cloquet (*Anat. Descript.* t. ii. p. 88.) goes still further than Scarpa, and describes seven longitudinal striæ, three of which are grey, and four white. Scarpa has very justly remarked, that the proportion of ash-coloured or grey substance is much more considerable in the fœtus, that it diminishes in the adult, and that it scarcely if at all exists in the old subject.

optic commissure), or rather the two optic nerves unite before they pass to their respective destinations.

On turning the cerebellum forwards, it is seen that the optic tracts (2, *fig.* 295.) are continuous with the corpora geniculata externa (*b*), and consequently take their origin from the optic thalami (*a*), of which these bodies are a dependence. In some cases, the white ribbon-like band, or *optic tract*, which constitutes the origin of the optic nerve, is also continuous with the corpus geniculatum internum (*c*). In the human subject, the optic nerves never arise, either entirely or in part, from the anterior tubercula quadrigemina (nates); it is only by induction that this mode of origin has been admitted in the human subject.*

The optic tract (2, *fig.* 272.), having arisen from the corpus geniculatum externum (above *i*) with which it is continuous, without any other line of demarcation excepting the difference of colour, assumes the appearance of a thin and broad ribbon, which turns round the cerebral peduncle (*v*) parallel to and on the inner side of the great transverse fissure of the brain. During this course, it lies in contact with the peduncle of the cerebrum, from which it may be separated without laceration, excepting at its outer border, by which it adheres so intimately that the peduncle has been supposed to supply it with several roots.

As soon as it gets beyond the peduncle, the optic tract (*s*, *fig.* 276.) is condensed into a flat cord, which leaves the peduncle, passes inwards and forwards, and unites with its fellow of the opposite side, to form the *chiasma* (square space of Zinn, *t*), or rather to form with the optic tract of the opposite side, a commissure which is convex in front and concave behind.

On leaving the commissure, it completely changes its direction (2), passing forwards and outwards, to enter almost immediately into the optic foramen (2, *fig.* 296.).

During its course in front of the peduncle of the cerebrum, it is in relation with the following parts: *behind*, with the tuber cinereum (*v*), from the interior of which some white fibres arise, and pass to the chiasma; *in front*, with the membrane which forms the anterior portion of the floor of the third ventricle and which is prolonged upon the upper surface of the chiasma.

An important question here presents itself, viz. Is there a complete or partial decussation of the optic nerves in the commissure? Do these two nerves interlace without decussating, or rather is there an intimate mixture of their fibres? Are the nerves placed in simple juxtaposition and united by a transverse band? Lastly, does the chiasma constitute a commissure in which the two optic tracts terminate, or rather which serves as a point of origin for the optic nerves? All these opinions have found supporters, and facts have been quoted in favour of each; a circumstance which proves, not that there are anatomical varieties in the structure of the chiasma, but that its structure is of a complex nature.

Comparative anatomy proves that the optic nerves decussate in the commissure: in fishes, the two nerves cross without uniting: it is also proved by

* The origin of the optic nerves varies in the different classes of animals. In birds, in which these nerves are at their maximum development, they arise entirely from the tubercula quadrigemina, which are the *optic lobes* in these animals, and are transposed from the side to the base of the brain. The optic thalami do not assist in forming these nerves. In rodentia, a small number of fibres from the optic thalami join the mass of those which are derived from the nates. In carnivora, the number of filaments from the tubercula quadrigemina and from the optic thalami are almost equal. Moreover, if it be remembered that the tubercula quadrigemina, the corpora geniculata externa and interna, and the optic thalami themselves, belong to the same system of organs, and form a continuation of the reinforcing fasciculi (*faisceaux innominés*) of the medulla oblongata; and if other facts confirmatory of the preceding also be taken into consideration, namely, that a white band proceeds on each side from the natis to the corpus geniculatum externum, and another from the testis to the corpus geniculatum internum; it will be easy to account for these varieties of origin, which can all be reduced to the same type. It is of some importance in regard to this question, that in a great number of cases of atrophy of the optic nerve which I have had occasion to examine in the human subject, the corpus geniculatum externum was affected, and not the natis.

pathological facts; in a great number of cases of atrophy of one eye, atrophy of the nerve extended, beyond the commissure, to the opposite optic tract.

On the other hand, in an equally large number of cases of atrophy of one eye, the disease affected the optic tract of the same side, so that this would seem to show that there was no decussation.

Lastly, in all cases of atrophy of one eye, the disease affects one of the optic tracts in particular, but the other has always appeared to me to be evidently reduced in size.

On attempting to determine the point, either by the dissection of optic nerves hardened in alcohol, or unravelled by means of a stream of water, it is seen that these nerves present the following threefold arrangement at the commissure. The external fibres of the commissure do not decussate; the internal fibres (and these are the most numerous) do decussate; and the posterior fibres are continued from one side to the other, like a commissure.

Structure. The optic nerve has a peculiar structure. It does not commence by filaments of origin or distinct cords, like the other nerves, but the optic tracts and the optic commissure are composed of two medullary bands, the fibres of which are parallel and in immediate contact with each other, precisely as in the olfactory nerves, and in the cerebral substance *; after leaving the commissure, the optic nerves are enveloped in a neurilemmatic sheath, from the internal surface of which certain prolongations or septa are given off which divide the interior of the nerve into longitudinal canals, in which the medullary substance is contained.

The optic nerve, therefore, does not consist like other nerves of a plexiform group of nervous filaments or cords, but of a collection of canals closely applied to each other, so that it has the appearance of the pith of the rush; hence, doubtless, the opinion of Eustachius and some other authors who conceived that the optic nerve was traversed by canals; and hence also the error of Reil, who, having taken the structure of the optic nerve as the type of that of all nerves, regarded each nervous cord as containing a central canal. †

The Central Extremity of the Common Motor Nerve of the Eye.

The *apparent origin* of the *motor nerves of the eyes* (3, *fig.* 276.), motores oculorum, *common oculo-muscular* nerve, or third pair, have a penicillate character; these origins consist of a linear series of very delicate filaments proceeding from the fasciculi found between the peduncles of the cerebrum, in the depression between the pons Varolii and the corpora albicantia. Some filaments converge from the cerebral peduncles themselves. ‡ This origin extends about a line and a half, in a direction obliquely inwards and forwards. The internal filaments of origin reach the middle line, so that Varolius and Vieussens believed that the nerves of the right and left sides are continuous, and explained the simultaneous action of the two eyes by this anatomical arrangement.

Real origin. In a brain hardened by alcohol, or still better in the brain of a fœtus, the filaments of origin of the nerve (3, *fig.* 295.) can be easily traced into the substance of the median fasciculi (*d*) found between the peduncles of

* See note, p. 1026.

† In most fishes, whose faculty of vision is exercised in a less transparent medium than air, the optic nerve is formed by a membrane folded upon itself. In birds of prey, the membrane is sometimes folded like a fan, sometimes like the leaves of a book. These folds are intended to increase the extent of surface, and to augment the power of vision. Malpighi first made this observation upon the optic nerves of some fishes. Desmoulins, who has studied the point more carefully, has shown that it is in relation with the perfection of the sense of sight. The same thing is also observed in the retina: thus in the eagle, the retina presents two, three, or four superimposed folds; so that each luminous ray acts upon sixteen surfaces instead of upon two.

‡ In fact the external filaments often arise from the inner border, and even from the lower surface of the cerebral peduncle, at a certain distance from the inner border; in this case they do not arise from the peduncles, but merely pass through them. The same is doubtless the case with the filaments of origin which Ridley and Molinelli state that they have seen coming from the pons. I have never met with this origin from the pons, nor with that accessory nerve which Malacarne has described as proceeding from the upper part of the peduncle of the cerebellum, turning round the border of the pons, and joining the motor oculi nerve.

the cerebrum, and which have already been shown to be prolongations of the fasciculi of reinforcement (*faisceaux innominés*) of the medulla oblongata. The filaments of the nerve traverse these fasciculi in a diverging manner, and descend to a level with the pons, beyond which I have not been able to trace them on account of their slenderness and divergence. I have never observed any of them running towards the corpora albicantia, and reaching the walls of the third ventricle or the anterior commissure as has been stated by some. Nor have I found that they are reinforced, as Gall believed, in the blackish substance (*locus niger*) which separates the peduncles of the cerebrum, properly so called, from the prolongations of the reinforcing fasciculi of the medulla oblongata.

Fig. 295.

Cranial course. Having arisen in this manner, the fibres of the motor oculi nerve converge into a flat bundle which passes between the posterior cerebral and the superior cerebellar arteries, upon which latter it is reflected: on emerging from the interval between these two vessels it becomes rounded, and then, passing upwards, outwards, and forwards, enters the reticular subarachnoid cellular tissue at the base of the brain, and gains the side of the sella turcica (3, *fig.* 296.), where it enters a proper sheath formed for it by the dura mater.

The Central Extremity of the Pathetic Nerve.

The *nervi pathetici* (4, *fig.* 276.), *nerves of the superior oblique muscle of the eyes*, *nervi trochleares*, *the internal and superior oculo-muscular* nerves, or the fourth pair, as they are variously called, are the smallest of the cranial nerves, and are as remarkable for being exclusively distributed to the superior oblique muscle of the eyes, as for their origin and for the length of their course within the cranium. The term *patheticus* is derived from the opinion that the superior oblique muscle is especially concerned in the expression of love and of compassion. According to Bell, this nerve is the *respiratory nerve of the eye.*

The *apparent origin* of this (4, *fig.* 280.) nerve is below the tubercula quadrigemina, on each side of the valve of Vieussens, sometimes by one, sometimes by two, and even by three or four roots. Occasionally there are several roots on one side, and only a single root on the other. The nerves of the two sides are often united by some white streaks which form a transverse commissure; at other times they do not arise at the same level.

Real origin. It has been supposed that some fibres come from the testes, others from the cerebellum, and that others commence much lower down than the apparent origin: all that can be seen is that these nerves (4, *fig.* 295.) arise from the valve of Vieussens, to which they adhere so slightly, that the least force is sufficient to detach them.

Cranial course. Immediately after its origin, the pathetic nerve turns forwards and downwards, around the isthmus of the encephalon, in front of the anterior border of the cerebellum, and thus reaches the base of the cranium (4, *fig.* 276.) accompanied by the superior cerebellar artery, between the fifth and third cranial nerve, but much nearer to the fifth; it then passes directly forwards upon the side of the sella turcica (4, *fig.* 296.), and perforates the dura mater, considerably below the third nerve. During its whole course, it is situated between the arachnoid and the pia mater, in the reticular cellular tissue found in this region.

Wrisberg says, that the right pathetic nerve is larger than the left. Ruysch states that he found this nerve double, which it is difficult to believe, unless he meant to say that it bifurcated at its origin. Vesalius regarded this nerve as

a root of the third cranial nerve; other anatomists have considered it as a dependence of the fifth.

The Central Extremity of the Trigeminal Nerve.

Apparent origin. The *trigeminal*, or *trifacial nerves* (5, *fig.* 276.), the *middle sympathetic*, or the fifth pair, are the largest of the cranial nerves, excepting the optic: they arise at the sides of the pons Varolii, at the point where the pons becomes continuous with the corresponding peduncles of the cerebellum, and exactly where the middle fibres of the pons cross in front of the inferior, to form that peduncle, so that the fasciculi of origin appear to converge from a narrow slit in the pons itself. This origin (5, *fig.* 295.) consists of two roots, the *large* and the *small* root, which have a small prominence between them. The *large* or *ganglionic root* is a thick, fasciculated mass, which is as it were constricted at its point of emergence, but immediately expands into a thick flat bundle, in which we may count about 100 fibres. On tearing off this bundle, all the fibres do not give way opposite the same place, and a sort of mamillary prominence is left, which Bichat regarded as belonging to the pons, as intended for the nerve to arise from, and as having the effect of multiplying the surfaces of origin, in consequence of its convexity.

The *small root*, which is non-ganglionic, is composed of small and very distinct bundles, which arise from the pons, above and behind the great root, by several cords; it emerges from the pons through a fissure distinct from that for the great root, and gains the upper border of that root.

It will hereafter be seen that the small root has no share in the formation of the gangliform plexus known by the name of the *semi-lunar* or *Gasserian ganglion*, and that it goes exclusively to assist in forming the *inferior maxillary* division of the fifth nerve.

Real origin. Until modern times, the origin of the fifth nerve had not been traced beyond the point of its emergence. Late authors have described its real origin with so much detail that little remains to be desired. Gall, while examining the fifth nerve, first in mammalia and then in the human subject, saw that in many the origin of the nerve is concealed by certain transverse fibres of the pons which do not exist in the lower animals. Having traced the nerve by clearing off the fibres of the pons, he thought he observed that the great root divided into three principal fasciculi, which he conceived arose in succession from the grey matter of the pons, and which he succeeded in tracing as far as to the outer side of the olivary body.*

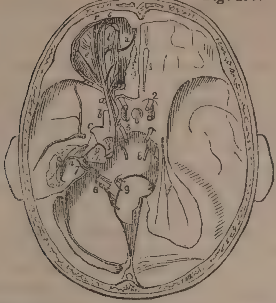
Rolando, by successive sections made through the pons towards the medulla oblongata, has clearly shown that the great root of the fifth nerve consists of only one fasciculus, which runs downwards and backwards under the form of a thick cord (see *fig.* 295.) in the substance of the pons, or rather at the boundary between the pons and the middle peduncle of the cerebellum, parallel to the fasciculi of the anterior pyramid, and that it progressively diminishes in size until it disappears opposite to the inferior angle of the fourth ventricle. The examination of this origin in a brain hardened by alcohol, or still better in the fœtal brain, confirms Roland's observations, and proves that the great root of the fifth nerve comes from the back part of the medulla oblongata, from the interior of its fasciculi of reinforcement (*faisceaux innominés*).† As to the small root, it cannot be traced beyond the surface of the pons.‡

* In the human subject the origin of the fifth nerve is extremely deep seated; it is not so deep in the carnivora, and still more superficial in ruminantia. In oviparous animals, which have neither a pons Varolii, nor lateral lobes of the cerebellum, nor pyramids, nor olivary bodies, the origin of the fifth pair is seen without any dissection.

† Vicq d'Azyr says that the roots of this nerve extend as far as the cerebellum, but this assertion has not been verified. The same anatomist declares that he has often seen the fifth nerve of the right side larger than that of the left.

‡ According to Dr. Alcock, there is a slight enlargement at the origin of the large root of the fifth nerve, in the lower part of the floor of the fourth ventricle; he has also traced the small root to this enlargement, from which he states that two cords descend, one to the anterior, the

Fig. 296.



Cranial course. After emerging from the pons the fifth nerve passes upwards, outwards, and forwards, under the form of a flattened bundle, gains the upper border of the petrous portion of the temporal bone (5, *fig.* 296.), on which there is a depression that is converted into a canal for the nerve by a fold of the dura mater; the nerve is reflected upon this border, and proceeds as will presently be described.

The Central Extremity of the External Motor Nerve of the Eye.

The *external motor nerves of the eye* (6, *figs.* 276. 295.), *external oculo-muscular* nerves, nervi abducentes, or the sixth pair, which are distributed exclusively to the external rectus or abductor muscle of each eye, and which are so remarkable for their communications with the sympathetic system, are smaller than all the cranial nerves, excepting the pathetic.

Apparent origin. The statements of authors regarding the apparent origin of this nerve have been singularly various: some, with Morgagni, describe it as arising both from the pons and the anterior pyramids; others, with Vieussens, from the pons alone, and others, with Lieutaud, from the anterior pyramids only. Winslow states that it arises between the pons Varolii and the olivary body, and Haller that it proceeds from the furrow between the anterior pyramid and the pons.

The fact is that this nerve, among some varieties of origin, presents two very distinct roots (see *fig.* 276.): one *internal* and smaller, which arises from the pons, either at or near its lower border; the other *external* and larger, which appears to emerge on the outer side of the upper part of the anterior pyramid. These two roots are fasciculated: not unfrequently some fibres are seen arising from the olivary body, or from the furrow between the two pyramids.

Real origin. This is more easily seen in mammalia generally than in man. In the former, Gall has traced it along the side of the pyramids. Mayo believes that the fibres traverse the pons, and pass to the back part of the medulla oblongata. From the tenuity and whiteness of the fibres of this nerve I have not been able to trace their course in the substance of the medulla.

Cranial course. This nerve runs upwards and a little outwards, on the side of the basilar groove, and perforates the dura mater (6, *fig.* 296.) opposite to and above the apex of the petrous portion of the temporal bone to enter the cavernous sinus: the two roots of the nerve often unite before perforating the dura mater, but they usually pass separately through it and unite within the sinus.

The Central Extremity of the Seventh Nerve.

The *central extremity of the facial nerve* or *portio dura of the seventh nerve* (7, *fig.* 270. 276.) The facial nerve (on the inner side of 7) arises in the deep depression between the middle peduncle of the cerebellum and the pons in front of the auditory nerve (on the outer side of 7): it emerges from the front of the restiform body, under the form of a fasciculated band, some fibres of which are at first situated at a distance from the general mass, but soon join it; it then turns round the lower borders of the peduncle of the cerebellum, against

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other to the posterior column of the cord. (*Cyclop. of Anat. and Phys.* art. FIFTH PAIR OF NERVES.)]

which it is closely applied, and then becoming free passes outwards and upwards. It has no neurilemma up to the point where it becomes free.

The *real origin* of this nerve (7, *fig.* 295.) is much deeper; it may be traced through the restiform body into the fasciculus of reinforcement, near the median furrow of the calamus scriptorius.

The *central extremity of the auditory nerve.* The *auditory nerve*, or *portio mollis of the seventh* (on the outer side of 7, *fig.* 275.), is ribbon-shaped, and non-fasciculated at its origin: it arises (7′, *fig.* 295.) in the same depression as the facial nerve, but behind that nerve, and opposite to the restiform body: it presents two very distinct roots: an anterior, which is arranged like the facial nerve; and a posterior, which turns horizontally round the back part of the restiform body, appears upon the posterior surface of the medulla oblongata (see *fig.* 271.), and separates into fibres which may be traced as far as the median furrow of the calamus scriptorius, and which represent some of the barbs of the quill. It is very generally admitted that the auditory nerves have a transverse commissure, but this does not appear to me to be clearly demonstrated.

The portio dura and the portio mollis of the seventh nerve, which arise so near to each other, follow the same *cranial course*: they arise at the same height from the medulla oblongata, pass outwards and upwards in front of the pneumogastric or subpeduncular lobule of the cerebellum, and enter the internal auditory meatus (7, *fig.* 296.). During this course, the portio dura always lies in front of the portio mollis.

The auditory nerve is the softest of all the cranial nerves; the difference between it and the facial nerve, in this respect, has led in a great measure to the subdivision of the nerves into the soft or sensory, and the hard or motor.

The Central Extremity of the Eighth Nerve.

Of the three nerves on each side which together constitute the eighth nerve (8, *figs.* 270. 276. 295.), the *glosso-pharyngeal* is the highest, the *pneumogastric* is the next, and the *spinal accessory* is the lowest.

The *central extremity of the glosso-pharyngeal* and *pneumogastric nerves.* The *glosso-pharyngeal* and *pneumogastric nerves* have a common origin. They arise like the spinal nerves by a linear series of funiculi (see *fig.* 270.), which come off, not from the furrows between the olivary and restiform bodies but from the restiform body itself, on a line with the auditory nerves. Sommerring states that he has seen some of these funiculi arise from the anterior wall of the fourth ventricle.

Moreover, as in the spinal nerves each funiculus of origin is formed by the union of two or three converging filaments; the funiculi of the glosso-pharyngeal nerve, which are the highest and which come off immediately below the auditory nerve, are not distinct at their origin from those of the pneumogastric: nor. as will presently be stated, are the funiculi of origin of the pneumogastric distinct from those of the spinal accessory. The *division* into the three nerves cannot be made until after the funiculi are finally grouped.

It has been stated, but without proof, that the fibres of the glosso-pharyngeal and pneumogastric nerves might be traced through the restiform body as far as the back of the medulla oblongata. The funiculi of origin of these nerves, which are enveloped by the neurilemma at the point where they emerge from the medulla, are so small that, when torn off, scarcely any trace of their points of attachment can be detected even by the aid of a lens.

The *central extremity of the spinal accessory nerve of Willis.* The *origin of the spinal accessory nerve* (*s fig.* 295.) is quite peculiar, and has obtained much notice from modern anatomists.

It arises from the sides of the cervical region of the spinal cord between the anterior and posterior roots of the cervical nerves, and behind the ligamentum denticulatum. Sir. C. Bell, who classes it among the respiratory nerves,

strongly insists upon its origin from that column of the cord which is situated between the anterior and posterior columns, in a line with the pneumogastric and facial nerves, which column (the *respiratory tract*) he assumes to give origin solely to the respiratory nerves. The funiculi of origin of the spinal accessory vary much both in number and size, and are widely separated from each other; the lowest as well as the highest funiculi appear to me to be continuous with the posterior roots of the spinal nerves; and again, the highest are continuous above with those of the pneumogastric nerve, and appear to me to establish a transition between the origin of that nerve and the posterior roots of the spinal nerves.

The lowest funiculus of the spinal accessory is generally situated not lower than the fifth cervical nerve; it has been seen to arise opposite the sixth and even the seventh cervical nerve; the latter is the normal condition in the ox.

It is of importance to remark the connexion which exists between the spinal accessory nerve and the first cervical or sub-occipital nerve. Almost always one or two, and frequently all of the posterior funiculi of the sub-occipital join the spinal accessory. Not unfrequently a small funiculus joins the spinal accessory from the second cervical nerve. Opposite its connexion with the sub-occipital nerve, the spinal accessory sometimes presents a gangliform enlargement which was well described by Huber (*in ganglion vix hordeaceum intumescit nervus accessorius*). In some cases, a filament proceeds from this ganglion and joins the anterior roots of the sub-occipital nerve. Winslow believed that the funiculi of origin of the spinal accessory communicated with the hypoglossal: this is an error. The greater number and even the whole of the funiculi of the sub-occipital nerve have been seen to join the spinal accessory, in which case, filaments from the latter nerve always supply the place of those which are usually furnished by the first cervical.*

The cranial course of the glosso-pharyngeal and pueumogastric nerves. They pass horizontally outwards, in contact with the lateral fibrous layer of the fourth ventricle, forming two groups having a very small interval between them. The two, three, or four small bundles which constitute the glosso-pharyngeal nerve pass through a special opening in the upper part of the foramen lacerum posterius (8, *fig.* 296.). The bundles which form the pneumogastric nerve are collected together and pass through the same foramen but by a distinct opening from the preceding one.

The *cranial* or rather the *vertebral course of the spinal accessory nerve of Willis* is remarkable. This nerve, which is very small below, where it is formed by one or two funiculi, ascends vertically upon the side of the cervical region of the spinal cord, to which it is closely applied below, just behind the ligamentum denticulatum, and from which it is separated above, where it is immediately in front of the posterior roots of the cervical nerves; it goes on increasing in size as it receives additional funiculi which are blended with it; having arrived a few lines below the posterior lacerated foramen, it passes upwards and outwards to enter the same opening as the pneumogastric, being situated below that nerve, and emerging with it from the cranium.

The Central Extremity of the Hypoglossal Nerve.

The *hypoglossal nerves* (9, *fig.* 276. 295.), or *ninth pair*, arise on each side, from the furrow between the olivary and pyramidal bodies, in the same manner as the spinal nerves, *i. e.* by a linear series of funiculi placed one above the other.

The furrow from which the funiculi of the ninth nerve arise is continuous with the line formed by the origins of the anterior roots of the spinal nerves; no funiculus arises from the line formed by the posterior roots.† The relation of the origin of the ninth nerve with the vertebral artery in front, and the

* Lobstein, *De Nervo Spinali.* Vide Scriptor. Neurol. Minor de Ludwig. t. ii.

† [In the ox and dog Mayer discovered a small posterior root with a ganglion for this nerve; and he states that he once found a small posterior root on one side in the human subject.]

vascular ramifications which surround the funiculi of this origin, require to be mentioned.

The *real origin* of the ninth nerve cannot be traced beyond its apparent origin. It is certain that no fibres come from the pyramids : it has appeared to me that the fibres entered the substance of the olivary bodies, in which they could not be traced to any depth.

Cranial course. All the funiculi of origin of the hypoglossal nerve commence by two or three filaments, which are immediately covered by the neurilemma; they are then grouped into two or three bundles which pass horizontally outwards to the anterior condyloid foramen, through which (9, *fig.* 296.) they almost always pass separately. Thus the dura mater forms two and sometimes three distinct canals for the hypoglossal nerve.

DISTRIBUTION OF THE CRANIAL NERVES.

The first pair or Olfactory nerves. — The second or Optic nerves. — The third or Common Motor nerves. — The fourth or Pathetic nerves. — The fifth or Trigeminal nerves — the Ophthalmic division of the fifth, and its lachrymal, frontal, and nasal branches — the ophthalmic ganglion — the Superior Maxillary division of the fifth, and its orbital branch — the spheno-palatine ganglion, and its palatine, spheno-palatine, and vidian branches — the posterior and anterior dental, and the terminal branches of the superior maxillary nerve — the Inferior Maxillary division of the fifth — its collateral branches, viz. the deep temporal, the masseteric, buccal, and internal pterygoid, and auriculo-temporal—its terminal branches, viz. the lingual and inferior dental — the otic ganglion.—The sixth pair or External Motor nerves. — The seventh pair — the Portio Dura or the Facial nerve — its collateral branches — its terminal branches, viz. the temporo-facial and cervico-facial — the Portio Mollis or Auditory nerve. — The eighth pair — its first portion or the Glosso-pharyngeal nerve — its second portion or the Pneumogastric nerve, divided into a cranial, cervical thoracic, and abdominal part — its third portion or the Spinal Accessory nerve. — The ninth pair or the Hypoglossal nerves. — General View of the Cranial nerves.

THE FIRST PAIR, OR THE OLFACTORY NERVES.

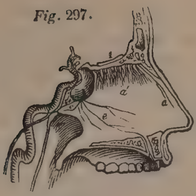
Dissection. Harden the nerve in dilute nitric acid. Examine the pituitary membrane, not from its free surface, but from the surface which adheres to the periosteum. The nerve ramifies between the periosteum and the pituitary membrane.

Before the time of Scarpa, the olfactory pedicles or bands and the ethmoidal bulb were the only parts well known ; the passage of the olfactory nerves through the foramina of the cribriform plate, and their distribution in the pituitary membrane were scarcely noticed.

Passage of the olfactory nerves through the cribriform plate. I must here remind the student that the cribriform plate of the ethmoid bone is perforated by foramina, or rather by different sets of canals which ramify in its substance ; that some of these canals terminate directly upon the roof or upper wall of the nasal fossæ, and that the others are divided into an internal set, which pass along the septum and end by becoming grooves, and an external set, which descend on the superior and middle turbinated bones and on the rough quadrilateral surface in front of them.

The olfactory nerves arise from the ethmoidal bulb (1, *fig.* 296, 297.) by a considerable number of white bundles which immediately pass through the cribriform plate, and divide and ramify (*d fig.* 297.) in the same way as the bony canals themselves ; the dura mater forms a sheath for each of the subdivisions of the nerve, and supports their soft substance. All these nervous filaments are distributed upon the septum (*d*) and upon the external wall (*a*, *fig.* 299.) of each nasal fossa ; the anterior run forwards, the middle verti-

Fig. 297.



cally downwards, and the posterior backwards. Some of them only interlace as they leave the cribriform plate. They all expand into very delicate pencils. They are situated between the periosteum and the pituitary membrane, and none of them reach either the inferior turbinated bone, or the maxillary, sphenoidal, or ethmoidal sinuses; on the inner wall of each fossa they do not pass lower than the middle of the septum; and on the outer wall they do not descend below the middle turbinated bone.*

With regard to the ultimate termination of the fibres of the olfactory nerve, there has been a difference of opinion; some believe that they terminate in papillæ like those of the skin; and others imagine that they expand into a membrane, like the optic nerve in the retina and the auditory nerve in the membranous labyrinth. I have never seen them terminate otherwise than by pencils of extremely delicate filaments very closely applied to each other.

Function. The olfactory nerves are the essential organs of smell. Their distribution proves that the sense of smell resides essentially and exclusively in the roof of the nasal fossæ and the immediately adjacent parts.

The Second Pair, or the Optic Nerves.

The optic nerves have already been described from their origin to the optic commissure, and from the commissure to the optic foramina (2, *fig.* 296.); they pass through these foramina together with the ophthalmic arteries which are below them; they are also accompanied by a sheath formed by the dura mater and by a prolongation of the arachnoid; the latter being immediately reflected from them.

The optic nerve, which is flattened up to this point, becomes rounded on emerging from the optic foramen, and is received in a fibrous ring formed by the origins of the muscles of the eye; it here also changes its direction slightly, for instead of passing obliquely forwards and outwards, it runs almost directly forwards to the globe of the eye, which it enters behind, and somewhat below, and to the inner side (see *o*, *figs.* 237, 238. 240.). There is a very evident circular constriction at the point where the optic nerve enters the eye.†

During its course in the orbit, the optic nerve is surrounded by a great quantity of adipose tissue, which separates it from the muscles and nerves. The ophthalmic ganglion and the ciliary nerves and vessels are in immediate contact with it. It is accompanied, as far as the sclerotic, by a fibrous sheath given off from the dura mater, so that this nerve differs from all others, in being provided with two protecting sheaths, namely, a proper neurilemma, and a sheath formed by the dura mater. A section of the optic nerve also presents throughout its course that peculiar appearance resembling the pith of the rush, which we have already described as commencing at the commissure (see Central Extremity of the Optic Nerve).

As it enters the ball of the eye, the nerve loses its two sheaths, which appear to become continuous with the sclerotic, and is thus reduced to its pulp, which spreads out to form the retina. In some subjects the retina presents a distinctly radiated appearance around the abrupt termination of the nerve (see Globe of the Eye — Retina).

Function. The optic nerves are the nerves of vision; their continuity with the retina leaves no doubt of this being their function.

* In mammalia, and particularly in the horse, a cord arises from the olfactory nerve, runs downwards and forwards along the septum, parallel to and in front of the naso-palatine nerve, and terminates in the small incisory cavity which exists in the arch of the palate in the lower animals, and is thought by M. Jacobson to be the seat of a sixth sense.

† M. Arnold, in his beautiful plates of the nerves of the head, has represented two very delicate filaments as establishing a communication between the superior maxillary and the optic nerves.

The Third Pair, or the Common Motor Nerves of the Eyes.

Dissection. All the nerves of the orbit should be studied together. The frontal and lachrymal branches of the ophthalmic nerve and the fourth nerve may be first examined; then the orbital portion of the nasal branch of the ophthalmic, which will afterwards be traced into the nasal fossæ; next the common and external motor nerves, and, lastly, the ophthalmic ganglion and the optic nerve.

The *common motor nerve* has already been traced (3, *figs.* 298. 301.) from its origin within the peduncles of the cerebrum to the side of the quadrilateral plate of the sphenoid bone, below and to the outer side of the posterior clinoid process; in this situation (3, *fig.* 296.) it is received into a groove formed for it by the dura mater; it then perforates that membrane, enters the cavernous sinus, passes through it from behind forwards and a little outwards, and before entering the orbit divides into two branches of unequal size, of which one is *superior* and the other *inferior*.

The following are its *relations* in the cavernous sinus: it is situated in the substance of the external wall of the sinus, to the outer side of the internal carotid artery, above the external motor nerve, and to the inner side of the fourth nerve and of the ophthalmic branch of the fifth; it enters the orbit at the innermost, and consequently the widest part of the sphenoidal fissure.

It has no immediate relations with the other nerves that pass through the cavernous sinus, until it is about to enter the orbit; at this point it receives some very delicate filaments from the cavernous plexus of the sympathetic, and an equally small filament from the ophthalmic branch of the fifth nerve; after which, the external motor nerve * becomes situated below the common motor, whilst the frontal and pathetic nerves cross above it; the nasal branch of the ophthalmic is in contact with its outer side, and then passes between its two divisions.

As the common motor nerve passes through the sphenoidal fissure, the tendon of the external rectus forms a fibrous ring around it, which is quite distinct from the ring belonging to the optic nerve; this fibrous ring also surrounds the external motor nerve and the nasal branch of the ophthalmic.

The *superior terminal division* of the third nerve is much smaller than the inferior; it passes below the superior rectus of the eye, and immediately expands into a great number of filaments, one of which is very large, and runs along the outer border of that muscle. Almost all these filaments are intended for the superior rectus, which they enter by its under surface. Several of them are very small, and run along the inner border of the superior rectus to be distributed to the levator palpebræ superioris. The filaments for this last muscle are proportionally much smaller and less numerous than those for the superior rectus.

The *inferior terminal division* is the true continuation of the nerve both as regards its size and direction; it runs between the optic nerve and the external motor nerve, which is in contact with it, and which lies between it and the external rectus muscle, and almost immediately subdivides into three branches; an *internal*, which, passing beneath the optic nerve, gains the internal surface of the internal rectus and ramifies in that muscle; a *median*, which penetrates the inferior rectus; and an *external branch*, which is the smallest, and runs along the outer side of the inferior rectus as far as the inferior oblique, and enters that muscle at its posterior border, and almost at right angles. The *short thick filament* which enters the ophthalmic ganglion proceeds from the branch for the inferior oblique muscle. This filament for the ganglion sometimes arises separately, and appears to be a fourth branch of the inferior division of the third nerve.†

* It appears to me that there is a communication between the common and external motor nerves in the cavernous sinus.

† I have seen the branch for the inferior rectus arise by two roots, one from the branch for

Function. The common motor nerve supplies all the muscles of the eye, excepting the superior oblique and the external rectus. It is remarkably large, and is proportioned to the activity and frequency of contraction in these muscles. That the muscular nerves do not terminate in loops or arches may be well seen in these muscles.

THE FOURTH PAIR, OR THE PATHETIC NERVES.

The *pathetic nerve* (4, *figs.* 298. 301.) is remarkable for its extreme slenderness, for its origin upon the side of the valve of Vieussens, for the length of its cranial portion, and for its winding course around the peduncle of the cerebrum; it enters (4, *fig.* 296.) an opening in the dura mater upon the anterior extremity of the inner or concave border of the tentorium cerebelli, on the outer side of the common motor nerve; it runs in the substance of the external wall of the cavernous sinus, to the outer side and a little below the level of the common motor nerve (3), and directly above the ophthalmic division (*a*) of the fifth, to which it sends off a filament, and then, running along the upper surface of that nerve, communicates with it by several twigs; it then enters the orbit together with the frontal nerve, the principal branch of the ophthalmic, through the widest part of the sphenoidal fissure, passes inwards and forwards, leaves the frontal nerve, crosses obliquely over the superior branch of the common motor nerve and the back part of the levator palpebræ superioris and superior rectus of the eye, to reach the superior oblique, and, having previously ramified, enters the upper border of that muscle. During its course in the orbit, this nerve, like the frontal branch of the ophthalmic, is in contact with the periosteum.

The union of the ophthalmic branch and the pathetic nerve is so intimate that it has been imagined that the lachrymal nerve is always derived entirely from the pathetic, and not from the ophthalmic itself. But a careful dissection shows that this is generally incorrect. However, I have found the pathetic nerve in several subjects giving off a branch which united with another from the ophthalmic nerve to constitute the lachrymal nerve. This anastomosis took place at the bottom of the orbit. Another and well-founded view regards the pathetic nerve and the ophthalmic branch of Willis as forming a single nerve; in fact, in certain subjects they interlace so intimately, that it is impossible to separate them.

The branch for the tentorium cerebelli. The pathetic nerve, while still contained in the substance of the external wall of the cavernous sinus, gives off a branch which runs backwards in the substance of the tentorium cerebelli, and may be traced as far as the lateral sinus, near which it divides into two or three filaments. In several subjects I found that the branch for the tentorium was formed by a twig which arose from the ophthalmic nerve, became applied to the pathetic nerve, then diverged from it, and passed backwards in the substance of the tentorium. It appears, then, that the nerve of the tentorium has a retrograde course.*

Function. The fourth pair of nerves is intended for the superior oblique muscle only of the eye. It has been supposed that this muscle has a special nerve to enable it to express certain mental emotions, and especially love and pity; but, as Soemmerring remarks, it exists in all mammalia, in birds, and even in fishes.

Camper states that the vital functions of the pathetic survive those of the other nerves, and that this circumstance influences the direction of the eyes in dying persons.

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the internal rectus, and the other from the branch for the inferior oblique. I have seen the branch for the inferior oblique give off a supernumerary branch to the inferior rectus. Lastly, sometimes the branches for the inferior oblique and inferior rectus are united, so that the inferior division of the third nerve was subdivided into two branches only.

* Arnold has described the branch (*f*, *fig.* 296.) for the tentorium cerebelli, which is derived from the fifth nerve, and not that which comes from the pathetic.

According to Sir C. Bell, the pathetic is the respiratory nerve of the eye. Its origin is situated at the highest part of the respiratory tract. According to the same physiologist, it is the nerve of expression; it associates the muscles of the eye, and establishes certain relations between the eye and the respiratory system.

The Fifth Pair, or the Trigeminal Nerves.

The *nervus trigeminus* (trifacial, *Chauss.*; 5, *fig.* 296.), which, as already stated, arises from the side of the pons Varolii by two distinct roots, gains the upper border of the petrous portion of the temporal bone, over which it is reflected, and near the apex of which there is a depression for the reception of the nerve: a bridge-like fold of the dura mater converts this depression into a canal. The nerve, which increases in width as it passes over the upper border of the petrous bone, continues to get wider whilst upon the upper surface of the same bone, and runs downwards, forwards, and outwards; its fibres immediately spread out and interlace to enter the concave surface of a greyish semilunar enlargement, called the *semilunar* or *Gasserian ganglion*. All the fibres of origin of the fifth nerve do not assist in the formation of this ganglion; for on reflecting the nerve from within outwards, a flat cord (*b*, *fig.* 299.) is seen below the ganglion, and giving no fibre to it; and on tracing this cord upon the side of the pons Varolii, it is found to consist of the small root of the fifth nerve, which is at first placed on the inner side of this nerve, and then turns round it to gain its under surface.

This very remarkable disposition establishes a complete analogy between the fifth cranial nerve and the spinal nerves, which, as we have seen, have ganglionic roots (the posterior roots) and non-ganglionic roots (the anterior).

The *Gasserian ganglion* (behind *a b c*, *fig.* 298.; *c*, *fig.* 299.) is lodged in a special depression in the petrous portion of the temporal bone (*fig.* 296.), and it adheres so closely to the dura mater that it is impossible to separate the ganglion without tearing it. From its convex surface, which is directed forwards and outwards, proceed three plexiform nervous trunks, which diverge like the toes of a bird; these are, proceeding from before backwards, the *ophthalmic nerve of Willis* (*a*, *figs.* 296. 298., &c.), the *superior maxillary nerve* (*b*), and the *inferior maxillary nerve* (*c*): the non-ganglionic root (*b*, *fig.* 299.) of the fifth nerve goes directly to the inferior maxillary division (*c*) of the nerve: the ophthalmic and the superior maxillary divisions often arise by a common trunk. Several scattered filaments are given off from the three divisions of the nerve, but soon join them again. Communicating filaments are sometimes seen between the superior and inferior maxillary divisions as these latter enter their respective foramina.

Fig. 298.

The ganglionic nature of the Gasserian ganglion cannot be doubted; for, like all ganglia, it consists of a greyish, pulpy matter, in which the nervous fibres are spread out, and as it were entangled, to enter into new combinations.

The Gasserian ganglion* gives off several filaments for the dura mater, which may be traced into the substance of the tentorium cerebelli: a certain number of filaments appear to be destined for that part of the dura mater

* The Gasserian ganglion might serve as a type for demonstrating the structure of all ganglia, so easy is the separation of the grey matter and white fibres.

which covers the petrous portion of the temporal bone and the sphenoid bone. In order to demonstrate these twigs, the dura mater must be previously rendered transparent by maceration in diluted nitric acid.

The Ophthalmic Division of the Fifth Nerve.

The *ophthalmic nerve of Willis*, or *ophthalmic division of the fifth nerve* (nerf orbitaire, *Winslow;* orbito-frontal, *Chauss.; a, fig.* 296. &c.), is the highest and smallest of the three divisions: it passes forwards, outwards, and upwards, in the substance of the external wall of the cavernous sinus, in which situation it has a plexiform structure. It is there divided into an *external* branch, called the *lachrymal nerve* (*e, fig.* 296.), a *middle branch*, the *frontal nerve* (continuation of *a*), and an *internal branch* or the *nasal nerve;* these three branches enter the orbit through different parts of the sphenoidal fissure. Before this division, the ophthalmic nerve gives off a retrograde filament (nervus recurrens inter laminas tentorii, *Arnold; f, fig.* 296.), which passes backwards, closely applied to the twig furnished by the pathetic nerve to the tentorium cerebelli, and running parallel to that twig enters the tentorium.

The Lachrymal or Lachrymo-palpebral Nerve.

Dissection. First expose the nerve in the orbit, and then trace it backwards to its origin. This dissection is difficult, unless the parts have been macerated in diluted nitric acid. The nerve is then to be traced into the substance of the upper eyelid.

The *lachrymal nerve* (*e, fig.* 296.), the smallest of the three branches of the ophthalmic, comes off from the outer side of that nerve, in the substance of the external wall of the cavernous sinus, where it is difficult to discover its origin and course, on account of its intimate adhesion to the dura mater; it enters the orbit through the narrowest part of the sphenoidal fissure, runs along (below *s, fig.* 300.) the upper border of the external rectus, passes through the lachrymal gland, to which it gives several filaments, pierces the fibrous layer of the upper eyelid, descends vertically within that eyelid, between its fibrous layer and the orbicularis muscle, and divides into two principal cutaneous filaments; a *palpebral*, which runs along the lower border of the tarsal cartilage, and an ascending *temporal*, which is lost in the integuments upon the anterior temporal region. During its course, the lachrymal nerve gives off a *malar branch*, which may be regarded as resulting from a bifurcation of the nerve. This branch perforates the malar bone, and anastomoses with the facial nerve upon the cheek.*

The *lachrymal branches*, properly so called, are extremely small. The real termination of the lachrymal nerve is in the upper eyelid, and hence the term *lachrymo-palpebral* has been given it.

I have already said that the lachrymal nerve not unfrequently arises by two filaments, one of which is derived from the ophthalmic of the fifth, and the other from the pathetic nerve (Mr. Swan describes this as the usual condition). In a specimen which I have now before me, there are two lachrymal nerves, one of which arises in the ordinary manner, that is to say, from the ophthalmic division of the fifth, whilst the other, which is external and smaller, arises both from the pathetic and the frontal nerve. These two lachrymal nerves anastomose with each other.

The Frontal Nerve.

The *frontal nerve* (fronto-palpebral, *Chauss.*) may be regarded as the continuation of the ophthalmic (*a, fig.* 296.) both in size and direction; it enters

* Authors speak of a filament from the lachrymal nerve, which anastomoses with the superior maxillary nerve near the anterior extremity of the infra-orbital fissure. I have never seen this filament.

[Before reaching the lachrymal gland the lachrymal nerve may give off one or two communicating filaments, to join the temporal filaments of the orbital branch (*t, fig.* 300.) of the superior maxillary nerve before these latter perforate the outer wall of the orbit.]

the orbit at the highest and broadest part of the sphenoidal fissure, together with the pathetic nerve.*

It passes horizontally forwards, between the periosteum and the levator palpebræ superioris crossing that muscle at an acute angle, and divides at the bottom of the orbit, into two unequal branches which do not diverge until they reach the front of that cavity; these are the *internal frontal* and the *external frontal.*†

The external frontal or *supra-orbital nerve* (*r*, *figs.* 296. &c.). This is larger than the internal branch; it passes out of the orbit through the supra-orbital foramen, and expands into *ascending* or *frontal*, and *descending* or *palpebral* branches. The *palpebral branches* are very numerous, and descend vertically in the substance of the upper eyelid; one of these branches runs horizontally outwards under the orbicularis palpebrarum, to anastomose with the branches of the facial nerve. The *frontal branches* are generally two in number, an external, and an internal. They form the true continuation of the external frontal nerve which almost always bifurcates as it passes through the supra-orbital foramen; they are reflected upwards; the *external*, which is the larger, passes between the frontal muscle and the periosteum; the *internal* (*h*, *fig.* 285.) lies between the muscle and the skin; they both run somewhat obliquely upwards and outwards, spread out into ramifications which diverge from each other at acute angles, and may be traced as far as the lambdoidal suture. Almost all these ramifications are distributed to the skin. Some of them are periosteal, and these require for their proper demonstration that the parts should be macerated in diluted nitric acid: it is doubtful whether any of them terminate in the frontal portion of the occipito-frontalis muscle. In some subjects there is a very remarkable *osseous frontal branch* which enters an opening in the supra-orbital foramen, and passes along a canal formed in the substance of the frontal bone; it ascends vertically like the canal, gives off a succession of small periosteal filaments, and at length, emerging from the canal opposite to the frontal eminence, becomes subcutaneous.

The internal frontal or supra-trochlear nerve (*s*, *figs.* 296. 301.). This is almost always smaller, but is sometimes as large as the external frontal; its size appears to me to be inversely proportioned to that of the external nasal and external frontal nerves together; it is often divided into two branches; it passes out of the orbit between the supra-orbital foramen and the pulley of the superior oblique (hence it is called the *supra-trochlear* nerve), and divides into *ascending* or *frontal filaments*, which ramify in all that portion of the integuments of the forehead which lies between the branches of the right and left external frontal nerves, and into *descending* or *palpebral* and *nasal filaments* which descend vertically; the former set in the upper eyelid, and the latter upon the dorsum of the nose, where they anastomose with the branches of the nasal nerve.‡

When there are two internal frontal nerves, the inner one of them enters a fibrous ring formed in the upper part of the pulley for the superior oblique and divides into *palpebral* and *nasal* twigs, whilst the outer one supplies the *frontal* filaments. This outer nerve sometimes perforates the orbital arch from behind forwards in a special canal: I have seen it pass from without in-

* The orbital nerves which enter the sphenoidal fissure are divided into two sets; those which pass through the fibrous ring of the external rectus, namely, the common motor nerve, the nasal branch of the ophthalmic, and the external motor nerve; and those which pass above and to the outer side of the preceding, immediately below the lesser ring of the sphenoid bone, between the periosteum and the superior rectus, namely, the frontal branch of the ophthalmic, the pathetic, and the lachrymal branch of the ophthalmic: the latter nerve passes separately through the sphenoidal fissure.

† Not unfrequently a third branch arises from the inner side of the frontal nerve; this might be called the *fronto-nasal;* it passes obliquely inwards and forwards, crosses over the superior oblique, anastomoses with the external nasal nerve, emerges from the orbit below the pulley for the tendon of the superior oblique, and terminates with the external nasal nerve in the upper eyelid. [This fronto-nasal branch may arise from the internal frontal nerve.]

‡ [The supra-trochlear nerve supplies filaments to the corrugator supercilii, and to the orbicularis.]

wards to enter the frontal sinus, then run along the anterior wall of the sinus, and finally emerge through a special foramen at the side of the nasal eminence. This nerve gave no branch in the sinus, although it was situated between its anterior wall and the lining membrane.

I have seen the frontal nerve divided from its entrance into the orbit into four branches, of which the two outer ones corresponded to the external frontal and the two inner ones to the internal frontal nerve.

The Nasal Nerve.

Dissection. The orbital portion of this nerve is easily exposed between the optic nerve and the superior rectus. The external nasal branch can also be easily traced upon the frontal region. In order to see the internal nasal branch in the corresponding nasal fossa, an antero-posterior vertical section of the head must be made on one side of the septum nasi; this section will also serve for the demonstration of all the deep nerves of the face.

The *nasal nerve* (above *t, fig.* 301.), which is intermediate in size between the other two branches of the ophthalmic, viz. the frontal and lachrymal nerves, arises from the inner side of the ophthalmic, sometimes even as that nerve is entering the cavernous sinus; it is at first applied to the inner side of the ophthalmic nerve, and then to the outer side of the common motor nerve, together with which it enters the orbit, passing between the superior and inferior branches of that nerve. It then runs inwards and forwards, crosses obliquely over the optic nerve, passes below the superior rectus, then below the superior oblique, gains the internal wall of the orbit, and divides, near the upper border of the internal rectus, into two branches, named the *internal* and the *external nasal* nerves.

Before its entrance into the orbit, the nasal nerve gives off a *long* and *slender filament* (sometimes two), which enters the ophthalmic ganglion; it also furnishes one or more ciliary nerves, which run on the inner side of the optic nerve and are distributed like the ciliary nerves derived from the ophthalmic ganglion.

The *external nasal nerve* (palpebral, *Chauss.*). This branch (*t, figs.* 296, 301.) runs forwards, following the original direction of the nerve below the superior oblique, and emerges from the orbit by passing under the cartilaginous pulley for the tendon of that muscle (infra-trochlearis nerve, *Arnold*); it is sometimes joined by that division of the frontal nerve which I have named the fronto-nasal (note p. 1110.)* and divides into the following branches; *palpebral* filaments which run downwards and outwards in the orbicularis palpebrarum, and form anastomotic arches at the free margin of the upper eyelid; a great number of *nasal* twigs which pass upon the dorsum of the nose and anastomose with the filaments of the facial nerve which accompany the angular vein; and *frontal* twigs, which anastomose with those of the internal frontal nerve.†

The internal nasal or ethmoidal nerve (*u, fig.* 296.). The course of this nerve is very remarkable. It enters the anterior internal orbital canal which conducts it into the ethmoidal groove, on the internal surface of the basis cranii‡; it is then reflected forwards upon the side of the crista galli, passes though the ethmoidal fissure into the corresponding nasal fossa, becomes sensibly increased in size, and divides into two filaments, an *internal*, or *nerve for the septum*, and an *external*, or *naso-lobar* nerve.

* I have seen the external nasal nerve give off a branch which ran inwards, anastomosed with the fronto-nasal, perforated the roof of the orbit, ran for about an inch beneath the dura mater, perforated the frontal bone above and to the outer side of the frontal sinus, and was distributed to the skin upon the forehead.

† [It also supplies branches to the lachrymal sac and caruncula, and to the parts of the inner canthus.]

‡ Not unfrequently the internal nasal nerve, whilst within the ethmoidal groove, gives off a recurrent nervous twig, which enters the orbit by a small canal in front of the anterior internal orbital canal, and anastomoses with the external nasal or infra-trochlear nerve. I have seen this small nerve anastomose with the fronto-nasal branch, which I have already described (note, p. 1110.) as an unusual branch of the frontal nerve.

The *internal filament*, or *anterior nerve of the septum nasi* (*a, fig.* 297.), enters the fibro-mucous membrane upon the anterior part of the septum, and divides into several very slender filaments which may be traced below the middle of the septum.

The *external filament*, or *nerve of the external wall of the nasal fossa* (*u, fig.* 299.), runs along the anterior border of the septum, and divides into two terminal filaments, one of which passes upon the fore part of the external wall of the nasal fossa, and ramifies upon the turbinated bones; whilst the other and larger filament (*e;* naso-lobaire, *Chauss.*) follows the original course of the nerve, and passes behind the nasal bone, which is marked with a groove and frequently even by a canal for the reception of the nerve; from this latter filament several twigs proceed, which perforate the nasal bone more or less obliquely, and are distributed to the skin of the nose; having reached the lower border of the nasal bone, it passes forwards, increasing in size, through the fibrous tissue which unites the bone to the lateral cartilage of the nose, and then ramifies in the skin covering the ala and lobe of the nose, where I have seen it anastomose with the facial nerve.

Whilst within the cavity of the cranium the internal nasal nerve lies beneath the dura mater, and is perfectly distinct from the olfactory nerve, with which it never anastomoses.

*The Ophthalmic Ganglion and its Branches.**

Dissection. The ophthalmic ganglion may be exposed in several ways, for example, either in dissecting the branch given by the common motor nerve to the inferior oblique muscle, or directly by removing the adipose tissue between the external rectus and the optic nerve. The long branch from the nasal nerve to the ophthalmic ganglion and the ciliary nerves can also be exposed with the greatest ease.

The *ophthalmic* or *ciliary ganglion* (behind *i, fig.* 298.) is a small, greyish, and flattened enlargement, of a lenticular form (the *lenticular ganglion*), applied to the outer side of the optic nerve, and situated about two or three lines from the optic foramen, in the midst of a great quantity of adipose tissue, which renders its dissection difficult. It varies much in size, and sometimes consists of a simple miliary enlargement, which forms a point of origin and termination for a certain number of nerves. For the convenience of description, this ganglion is said to have four angles, two posterior and two anterior; by its *posterior and superior angle* it receives a long slender branch (*its long root*), given off from the nasal nerve whilst still contained within the cavernous sinus. Not unfrequently a second long but extremely slender root is furnished by the nasal nerve to the ophthalmic ganglion. By its *posterior and inferior angle* it receives a short thick branch, which comes from the inferior division of the common motor nerve (*its short root*). From its two *anterior angles* it gives off two small bundles of nerves, named the *ciliary nerves* (*i, fig.* 298.; *x, fig.* 301.). Lastly, the ophthalmic ganglion has a ganglionic or *soft root*, or rather a communicating filament between this ganglion and the superior cervical ganglion of the sympathetic; this soft root arises from the cavernous plexus, and passes sometimes to the long or nasal root of the ophthalmic ganglion, and sometimes to the ophthalmic ganglion itself.

The ciliary nerves are remarkable for their tortuous course, in which respect they resemble the ciliary arteries; and also for being collected into two bundles, the one *superior*, which is generally composed of four filaments, and the other *inferior* composed of five or six. The ciliary nerves do not anastomose before they reach the globe of the eye, with the exception, however, of the ciliary nerve which is derived directly from the nasal nerve and which anastomoses with an inferior ciliary nerve from the ophthalmic ganglion.

* The connexions of the ophthalmic ganglion with the nasal nerve, as well as with the common motor nerve, have induced me to describe it here.

Having reached the sclerotic, the ciliary nerves perforate that coat more or less obliquely, around the entrance of the optic nerve, excepting two or three which enter the globe of the eye near the attachment of the muscle; after having perforated the sclerotic, they become flattened or ribbon-shaped, and run forwards (*a*, *fig.* 242.) parallel to each other, between the sclerotic and the choroid coats, slightly adhering to the former of these membranes, on which grooves exist for their reception; on approaching the ciliary circle or ligament (*b*), they bifurcate, and divide into filaments which anastomose with the neighbouring filaments, and appear to be lost in the ciliary circle, which has been, and not without some reason, considered by modern anatomists as a nervous ganglion, *ganglion annulare* (annulus gangliformis seu ganglion annulare, *Soemmerring*). I have seen some of these ciliary nerves pass through the ciliary circle and enter the iris; they are not distinctly seen to enter the ciliary processes.*

The Superior Maxillary Division of the Fifth Nerve.

Dissection. Saw through the zygomatic arch, turn down the masseteric muscle, and remove the roof of the orbit; first dissect the lachrymal, malar, and temporal twigs of the orbital branch of the nerve; then clean out the orbital cavity, remove the upper wall of the zygomatic fossa to reach the spheno-maxillary fossa by means of two cuts joined at an acute angle in the foramen rotundum. Detach the origins of the pterygoid muscles; lastly, trace the nerve into the infra-orbital canal and on the face.

The *superior maxillary nerve* (*b*, *figs.* 298. 300, 301.), the second or middle division of the fifth nerve, both in position and size, runs forwards to enter, after a very short course, the foramen rotundum, by which it is conducted into the spheno-maxillary fossa; from thence it passes into and traverses the whole length of the infra-orbital canal, where it is named the *infra-orbital nerve* (*f*); having reached the fore part of that canal, it bends downwards, and ramifies in the cheek. It is plexiform at its origin and in the foramen rotundum, but is fasciculated throughout the rest of its course.

Its *collateral branches*, taken in the order of their origin, are the orbital nerve; certain nerves which are given off from the enlargement called Meckel's ganglion, namely, the palatine, spheno-palatine, and vidian or pterygoid nerves; the posterior dental nerves, and the anterior dental nerve; lastly, several small filaments come off either from the ganglion of Meckel, or from the superior maxillary nerve itself, and, surrounding the internal maxillary artery, assist in the formation of its plexus.

The Orbital Nerve.

This branch (*t*, *fig.* 300.) comes off immediately in front of the foramen rotundum, from the upper side of the superior maxillary nerve, passes through the spheno-maxillary fissure, along which it proceeds to enter the orbit; it then runs along the floor of the orbit, and divides into two branches: the one ascending, the *lachrymal branch of the orbital nerve*, which enters the lower surface of the lachrymal gland, anastomoses with the lachrymal branch (*s*) of the ophthalmic nerve (*a*), and sends off some branches to the upper eyelid, near its external angle; the other branch is the *temporo-malar*, which passes horizontally forwards, enters a small canal in the malar bone, and subdivides into a *malar filament*, which perforates the bone, and is distributed to the skin upon

* Tiedemann, from the results of observations in comparative anatomy, believes that the arteries which ramify in the retina are accompanied by very delicate nervous filaments, derived from the ophthalmic ganglion and the ciliary nerves: he has seen a nervous filament penetrate the optic nerve with the arteria centralis retinæ; and he states that the ciliary arteries are accompanied by very delicate nervous filaments, which he has traced into the retina as far as the zone of Zinn. Tiedemann also says that he has seen, only once it is true, a rather large nervous filament proceed from Meckel's ganglion and join the thick and short branch which is given off from the third pair to assist in the formation of the ophthalmic ganglion.

the malar region*, and a *temporal filament* which perforates the orbital portion of the malar bone and dips into the anterior part of the temporal muscle, in which it anastomoses with the anterior deep temporal nerve, a branch of the inferior maxillary. I have sometimes seen two temporal filaments pass through the malar bone at two different points.†

The Spheno-palatine Ganglion and its Branches.

After having given off the orbital nerve, and while it is still contained in the spheno-maxillary fossa, the superior maxillary nerve gives off from its lower side a thick branch, frequently two, and occasionally several branches, from which a great number of diverging nerves immediately proceed; these are the three palatine nerves, the spheno-palatine nerves, and the vidian nerve: at the point where these nerves diverge is found an enlargement which the elder Meckel ‡, whose name is connected with the description of the fifth pair, regarded as a ganglion, and which is therefore called *Meckel's ganglion*, or the *spheno-palatine ganglion* (situated before *s*, *fig.* 299.; below *b*, *fig.* 301.)

In a certain number of cases, I have sought in vain for the ganglionic structure in this enlargement, *i. e.* for grey matter with white filaments scattered through it. It appeared then to be nothing more than the common trunk or starting point of a great number of nerves; in the majority of cases, however, a quantity of grey matter certainly exists, but is so arranged, that the nerves may generally be traced quite through the enlargement, so that they clearly are not given off from the ganglion itself, but come directly from the superior maxillary nerve.§

I shall now describe in succession the branches which proceed from Meckel's ganglion.

The Palatine Nerves.

These nerves (*g g*, *fig.* 299.; *g*, *fig.* 301.) are three in number, an *anterior* palatine, which is the largest, a *posterior* palatine [the *middle* of some authors], which is the next in size, and an *intermediate* nerve [the *posterior* of some authors], which is the smallest; these nerves are continuous with Meckel's ganglion; it is most evident, that, in the greater number of cases, they arise directly from the lower part of the superior maxillary nerve.

The *anterior* or *great palatine nerve* immediately enters the posterior palatine canal, through the whole length of which it passes, and, having reached the lower orifice of that canal, is reflected forwards, and terminates by bifurcating on the hard palate.

Fig. 299.

During its course, it gives off an *inferior nasal branch* (lower *f*, *fig.* 299.) which is distributed over the middle meatus and the middle and inferior turbinated bones: the twig for the inferior turbinated bone may be traced to the fore part of that bone; it also gives off the anterior palatine, and several small twigs which perforate the inner wall of the maxillary sinus, and are distributed to the last molar teeth; lastly, at its exit from the posterior

* It is said that this twig anastomoses with the facial nerve in the malar region; I have never been fortunate enough to discover this anastomosis.

† [Both of these temporal filaments may be joined by communicating twigs from the lachrymal nerve within the orbit; one of them anastomoses with the anterior deep temporal nerve, as above-mentioned; the other, having entered the temporal fossa through the malar bone, ascends on the temporal surface of that bone, turns outwards, perforates the temporal fascia about an inch above the zygoma, anastomoses with filaments of the facial nerve, and of the auriculo-temporal branch of the inferior maxillary nerve, and is lost in the skin on the temple.]

‡ Mem. de l'Acad. de Berlin, 1749.

§ In one case the ganglion of Meckel was in contact with the internal surface of the superior maxillary nerve. In the same case a filament proceeded from the upper part of the ganglion, and joined the branch given by the external motor nerve to the sympathetic. I have not been able to discover the filaments which are said to establish a communication between Meckel's ganglion and the optic nerve.

palatine canal, and even sometimes whilst yet within that canal, it sends off a *staphyline* branch, which spreads into several filaments, all of which run backwards in the soft palate, and divide into *superior* filaments distributed to the mucous membrane on the nasal surface, and *inferior* which run beneath the mucous membrane on the buccal surface of the soft palate. Of the two terminal branches of the anterior palatine nerve, both of which occupy the hard palate, the external runs near the alveolar border, and the internal near the median line; they enter into the midst of the glandular layer of the palate and are ultimately distributed to the glands, to the mucous membrane of the hard palate, and to the gums.

The *posterior* [middle] *palatine nerve*, the next in size, enters a special canal: on escaping from which it passes backwards, beneath the mucous membrane of the nasal surface of the soft palate to which it is distributed.

The same is the case with the *intermediate* [posterior] or *small palatine nerve*, which is extremely slender.

I have seen a palatine nerve enter the maxillary sinus, run beneath its lining membrane, pass vertically through the maxillary tuberosity behind the last molar tooth, and ramify upon the hard palate.

The Spheno-palatine or Posterior Nasal Nerves.

Dissection. Make a vertical section of a head, previously macerated in dilute nitric acid, strip off the pituitary membrane lying upon the septum and the turbinated bones, and examine the nerves from the internal or deep surface of that membrane.

The spheno-palatine nerves are very slender; they enter the corresponding nasal fossæ through the spheno-palatine foramen, and have been traced by Scarpa with his customary exactness. They are all situated in the pituitary membrane, or rather, between the periosteum and the mucous membrane, and cannot be readily seen until this fibro-mucous membrane has been removed from the bones which it covers; the nervous filaments are then seen through the semi-transparent fibrous layer. For this purpose, preparations macerated in diluted nitric acid are indispensable. The spheno-palatine nerves are distributed to the septum nasi and the external wall of the corresponding nasal fossa; they are divided into *internal* and *external.*

There is only one *internal spheno-palatine nerve*, viz. the *nerve of the septum* nasi, or the *naso-palatine* of Scarpa (*b*, *fig.* 297.); it passes inwards, in front of the sphenoidal sinus, and below the orifice of that sinus, to gain the septum nasi; it is then directed at first almost vertically downwards, but afterwards almost horizontally forwards, as far as the superior orifice of the anterior palatine canal, which it enters, and then passes into a special canal, quite distinct from the anterior palatine canal, and parallel to the one for the naso-palatine nerve of the opposite side. According to M. Hippolyte Cloquet, the two naso-palatine nerves terminate in the upper part of a ganglion, which he calls the *naso-palatine*, and do not reach the mouth; but in some researches which I have made on the subject, I have failed in detecting this ganglion.*

The nerves can be distinctly seen to enter the mucous membrane of the hard palate behind the incisor teeth, and upon that prominence of the mucous membrane against which the point of the tongue is so often applied. I have never seen any anastomoses either between the two naso-palatine nerves, or between these and the anterior palatine nerves.

Anatomists are not agreed as to whether the naso-palatine nerve gives off any filaments upon the septum. I have failed in detecting any ramification of the nerve in a great number of preparations, in which the pituitary mem-

* I find that it is stated by Arnold, whom I have so often quoted, because his works are above all praise for their rigorous accuracy, that the spheno-palatine ganglion does not exist; and he observes with reason, that the subjoined description of M. Hippolyte Cloquet is very imperfect. "It consists of a small, reddish, fungous mass, rather hard, as if fibro-cartilaginous, and surrounded by adipose cellular tissue."

brane had been rendered transparent by long maceration in diluted nitric acid. Rather frequently a filament was given off from the upper part of the nerve, and then joined it again. Three times only did I observe a twig running upwards from the anterior part of the nerve.

The *external spheno-palatine*, or *superior nasal nerves* (upper *f*, *fig.* 299.), so called to distinguish them from the inferior nasal branch of the anterior palatine nerve, are three or four in number; they are directed vertically along the back part of the outer wall of the corresponding nasal fossa, and spread out into filaments which extend over the turbinated bones and the meatus; these filaments can only be seen from the deep surface of the pituitary membrane.*

I have never been able to find the anastomoses between the internal and external spheno-palatine nerves and the divisions of the olfactory nerve, which are admitted by some anatomists.

The Vidian or Pterygoid Nerve.

The *vidian nerve* (*v*, *figs.* 300, 301.) arises from the back part of Meckel's ganglion, and enters the vidian or pterygoid canal, after emerging from which it perforates the cartilaginous plate of the foramen lacerum anticus, and divides into a *superior cranial* branch, the great *superficial petrosal* nerve, and an *inferior*, *deep*, or *carotid* branch. The subdivision of the pterygoid nerve often occurs at its origin from Meckel's ganglion.

The *inferior* or *carotid branch*, which is much larger than the superior, forms the continuation of the nerve: it enters the carotid canal, and is applied to the outer side of the carotid artery, where it anastomoses with the nerves which establish a communication between the superior cervical ganglion and the external motor nerve of the eye, and assists in the formation of the carotid plexus; a flattened gangliform enlargement is seen at the point of anastomosis. I have sometimes seen two carotid branches, one of which was very small.

The *superior* or *cranial branch*, the *great superficial petrosal nerve*, enters the cranium between the temporal and sphenoid bones, runs backwards and outwards (*v*, *fig.* 296.) beneath the dura mater, in a groove on the upper surface of the petrous portion of the temporal bone, passes through the hiatus Fallopii into the aqueductus Fallopii or canal for the facial nerve (part of 7), and anastomoses with that nerve.† I say that it anastomoses, because there is a sort of fusion of the two nerves, and not a simple juxta-position. The branch called the chorda tympani, which comes off from the facial nerve at some distance from the point of fusion, should not be regarded as a prolongation of the superficial petrosal nerve, supposed in that case to be merely applied to the facial nerve.‡

* Bock, and Arnold after him, have described, under the name of the *pharyngeal branch*, a rather large branch, which may be regarded as belonging to the external spheno-palatine nerves; it enters into the pterygo-palatine canal, formed between the under surface of the sphenoid and the sphenoidal process of the palate bone, passes backwards and inwards, and divides into several filaments which are distributed to the upper part of the pharynx. [Some of these *superior nasal* branches are said to supply the lining membrane of the posterior ethmoidal, and the sphenoidal sinuses.]

† I have seen the superior branch of the vidian formed by three very distinct filaments: anatomists are still undecided as to whether the inferior or carotid branch is derived from the ganglion of Meckel, or from the superior cervical ganglion. According to Arnold, it resembles the organic system of nerves in its colour, softness, and structure. I cannot coincide in this opinion, for it appears to me that the cranial and carotid branches of the vidian are analogous in every respect.

‡ Arnold, who regards this opinion of Hippolyte Cloquet, which is adopted by Hirsel, as erroneous, states that, at the junction of the cranial branch of the vidian with the facial nerve, there is a gangliform swelling, in which he finds some analogy to the intervertebral ganglia, and which he considers to be a transition between a gangliform stalk and a true ganglion.

According to Arnold, the superficial or cranial branch, and the deep or carotid branch of the vidian do not come from a common trunk, but are merely juxta-posed, and are distinct throughout their entire extent. The carotid branch is soft and reddish, presents all the characteristics of the ganglionic nerves, and is intended to establish a communication between the superior

The Posterior Dental Nerves.

Dissection. These nerves can be readily seen without any dissection through the bone, when this is rendered transparent by nitric acid. They must be examined both from the external surface of the bone, and from the interior of the sinus.

The *posterior dental* or alveolo-dental nerves (*e, figs.* 298. 300, 301.) are two in number, a superior, and an inferior; sometimes there are three; they arise from the superior maxillary nerve, sometimes by a common trunk, sometimes separately, just as that nerve is about to enter the infra-orbital canal: they run forwards and downwards, at first in contact with the maxillary tuberosity, and give off some filaments to the buccinator muscle, and to the gums, and some which are distinctly distributed to the mass of fat in the cheek; they then enter certain canals in the substance of the maxillary tuberosity, and become flattened or ribbon-shaped.

The *posterior and superior dental nerve* passes from behind forwards through the base of the malar eminence of the superior maxillary bone and anastomoses on a level with the canine fossa with a filament from the anterior dental nerve.

The *posterior and inferior dental nerve*, which is larger than the preceding, runs in a curved direction below the malar eminence, the concavity of the curve being directed upwards, and anastomoses with the posterior and superior dental nerve on a level with the canine fossa. No filament is given off from the upper side of these nerves, but they give off a great number of filaments downwards which anastomose, and form a series of very remarkable meshes or areolæ; these meshes, and the dental nerves which come from them, are situated within the substance of the bone, but are much nearer to the sinus than to the outer surface of the bone. It is form these meshes that the extremely delicate filaments arise which form the dental nerves of the molars and bicuspids; their number corresponds to that of the fangs of these teeth.*

Some filaments evidently terminate in the substance of the superior maxillary bone; no other bone in the body has so large a number of proper filaments.

The Anterior Dental Nerve.

The *anterior* dental or alveolo-dental nerve (*j, fig.* 298.) is the only branch given off by the superior maxillary nerve whilst within the infra-orbital canal†; it arises about five or six lines from the anterior orifice of that passage. It is so large that it may be regarded as resulting from the bifurcation of the infra-orbital nerve. It soon enters a special canal formed for it in the superior maxillary bone, gives off on the outer side a small branch which anastomoses with the posterior and superior dental nerve, passes at first horizontally inwards, and then vertically downwards, turning round the margin of the anterior opening of the corresponding nasal fossa, and is reflected upon the floor of that fossa; during the whole of this course it is situated within the substance of the superior maxillary bone; its horizontal portion is superficial and its vertical portion is deep seated, having merely a thin bony lamella between it and the pituitary membrane. Having arrived on a level with the floor of the nasal fossa, about two lines from its anterior opening, it expands into a great number of ascending and descending filaments; the *ascending* filaments are reflected upwards within the anterior nasal spine where they terminate. They appear

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cervical and the spheno-palatine ganglion. The cranial or superficial petrosal branch, on the contrary, presents all the characters of the cerebro-spinal nerves; it is of a white colour, and firm consistence.

* In those molar teeth which have two or three roots, the nervous filaments subdivide and anastomose with each other in the substance of the dental pulp.

† Sometimes, however, I have seen the posterior and superior dental nerve arise within the infra-orbital canal.

to me to send off a small ramification to the pituitary membrane. The *descending filaments* terminate by supplying the dental nerves for the incisor, canine, and first bicuspid teeth. A great number of filaments are also lost in the substance of the bone.

I have never seen any filaments from the dental nerves entering the membrane of the maxillary sinus.

The Terminal Branches of the Superior Maxillary Nerve.

Having reached the anterior orifice of the infra-orbital canal, the superior maxillary nerve, the component bundles of which had been merely in juxtaposition, immediately expands (*i*, *fig.* 301.) into a pencil of diverging filaments beneath the levator labii superioris. These filaments (*i*, *fig.* 285.) may be divided into *ascending* or *palpebral*, which pass upwards and outwards beneath the orbicularis palpebrarum, and are distributed to the skin and conjunctiva of the lower eyelid; a great number of *internal* or *nasal* filaments, which run upon the side of the nose and are distributed to the skin of that organ; one of them runs along beneath the septum: and lastly into *descending* or *labial* filaments, which are the most numerous, and which enter the substance of the upper lip and are distributed to the skin and the mucous membrane; all these filaments, and especially the labial, interlace and anastomose with the facial nerve, so as to form a plexus, named the *infra-orbital*, to which we shall return in describing the facial nerve.

I have seen the nasal and the palpebral filaments arise together from the superior maxillary nerve before it had given off the anterior dental, enter a special canal situated on the inner side of the infra-orbital canal, emerge opposite the line of demarcation between the cheek and the nose, and then expand into their nasal and palpebral divisions; whilst the labial filaments had their usual arrangement.

The Inferior Maxillary Division of the Fifth Nerve.

Dissection. As this nerve must be examined both upon its internal and its external aspect, it must be dissected in both directions. An antero-posterior section of the head in the median line will enable us to see, on the internal surface of the nerve, the chorda tympani, the otic ganglion, and the origins of all the other branches which come from the inner side of the inferior maxillary nerve, viz. the nerve for the internal pterygoid, the lingual nerve, and the dental nerve. In order to see the distribution of the deep temporal, the masseteric, the buccal, the internal pterygoid, and the auriculo-temporal nerves, the inferior maxillary nerve must be exposed from its outer side, by breaking down the zygomatic arch, reflecting down the masseter which is to be detached as far back as the sigmoid notch, by sawing through the base of the coronoid process, and turning the temporal muscle upwards, and then by carefully dividing the external pterygoid muscle, through which the buccal nerve passes.

The *inferior maxillary nerve* (*c*, *figs.* 296, &c.), the most posterior and the largest division of the fifth nerve, passes outwards and a little forwards; and after a very short course within the cranium escapes through the foramen ovale into the zygomatic fossa, where it divides successively into seven branches. The non-ganglionic root (*b*, *fig.* 299.) of the fifth nerve is connected exclusively with the inferior maxillary division (*c*) of its other root, beneath which it lies, from which it can be distinguished by not having a plexiform structure, and with which it is not blended until it emerges from the foramen ovale. Of the seven branches of the inferior maxillary nerve, three are *external*—namely, the anterior and posterior deep temporal, the masseteric, and the buccal; one is *posterior*, namely, the auriculo-temporal; one is *internal*, the internal pterygoid; and two are *inferior*, the lingual or gustatory, and the inferior dental. These nerves may also be divided into the *collateral* branches, including the first five,

and the *terminal* branches, namely, the lingual and the inferior dental; the *otic ganglion*, described by Arnold, is connected with this nerve.*

The Collateral Branches of the Inferior Maxillary Nerve.

The Deep Temporal Nerve.

The first *external* branch, or the *deep temporal nerve*, arises from the outer side of the inferior maxillary nerve, passes horizontally outwards and forwards between the roof of the zygomatic fossa, with which it is in contact, and the external pterygoid muscle. Having arrived at the ridge which separates the temporal from the zygomatic fossa, it anastomoses with several temporal branches derived from the buccal and masseteric nerves, and forms a sort of plexus with them. The branches which emerge from this plexus ascend vertically in the deep layers of the temporal muscle, in which most of them terminate.

Some twigs anastomose with the temporal filaments derived from the lachrymal branch of the ophthalmic nerve, and from the orbital branch of the superior maxillary nerve.† One and sometimes two filaments perforate the temporal fascia, about a finger's breadth above the zygomatic arch, and then ascend beneath the skin to anastomose with the auriculo-temporal and the facial nerves.‡

The Masseteric Nerve.

The second *external* branch, or the *masseteric nerve*, arises from the same point as the last nerve, and greatly exceeds it in size; it comes off at an acute angle, passes horizontally backwards and outwards in contact with the roof of the zygomatic fossa, between it and the external pterygoid muscle; it is then reflected downwards over the upper part of that muscle to gain the sigmoid notch of the lower jaw upon which it is again reflected, and then descends vertically, between the ramus of the jaw and the masseter, or rather in the substance of the deep layers of that muscle, down to the insertion of which it may be traced. During its course along the upper wall of the zygomatic fossa, the masseteric nerve gives off a small deep temporal branch which runs along the periosteum, passes into the temporal fossa, and sends off an articular branch to the temporo-maxillary articulation.

The Buccal or Bucco-Labial Nerve.

The third *external* branch (*g*, *fig.* 300.), the *buccal* or rather the *bucco-labial nerve* (*Chauss.*), is very remarkable on account of its size and the extent of its distribution, which gives it some resemblance to the corresponding portion of the facial nerve. It arises from the outer side of the inferior maxillary nerve, by one, two, and sometimes three roots which perforate the external pterygoid, and join together as they emerge from that muscle; from thence it runs downwards between the coronoid process of the lower jaw and the tuberosity of the upper jaw, gives several twigs to the external pterygoid muscle, and also some branches to the temporal muscle, of which one ascends and anastomoses with the deep temporal nerve, whilst another descends and is distributed to the same muscle near its insertion into the coronoid process; the buccal nerve itself sometimes perforates the lowest part of the insertion of the temporal muscle, and having reached the back part of the buccinator, it expands into a great number of diverging branches, like the facial nerve.

The *ascending* branches are distributed to the skin of the malar and buccal

* We sometimes find a communicating filament between the superior and inferior maxillary nerves immediately before they enter their respective foramina.

† [There is hence a communication between the branches of the three divisions of the fifth nerve.]

‡ [This cutaneous filament is one of the temporal filaments of the orbital branch of the superior maxillary nerve. (*Ellis's Demonstrations*; see note, p. 1114.)]

regions; one of them forms an anastomotic arch with the facial nerve behind the duct of Steno. This anastomosis is very remarkable. The *middle* branches pass horizontally forwards on a level with the commissure of the lips, and terminate in the skin; several of them form a sort of plexus around the inferior coronary artery of the lip. The lowest of the *descending* branches pass vertically downwards and even a little backwards upon the outer surface of the buccinator, also beneath the deep surface and upon the outer surface of the triangularis oris, and are entirely lost either in the skin or in the mucous membrane. It is doubtful whether the buccal nerve partially terminates in the orbicularis oris, the triangularis oris, and the zygomaticus major. All the filaments which enter these muscles, and which appear at first sight to terminate in their substance, pass through them to supply the mucous membrane; their branches anastomose with the mental nerve beneath the triangularis oris; several filaments are lost in the buccinator.

The Internal Pterygoid Nerve.

The *internal* collateral branch (*t*, *fig.* 299.), or *nerve for the internal pterygoid muscle*, which is very slender, comes off from the inner side of the inferior maxillary nerve in contact with a greyish body, named the otic ganglion, runs downwards and inwards along the inner surface of the internal pterygoid muscle, and ramifies in it.

The Auriculo-temporal Nerve.

The *posterior* collateral branch, or the *auriculo-temporal nerve* (the *auricular* or *superficial temporal* nerve of authors), is very large, flattened, and plexiform at its origin (behind *c*, *fig.* 298.; *r*, *fig.* 299.); it sometimes arises by a great number of distinct roots; it passes backwards and a little downwards behind the neck of the condyle of the lower jaw, and divides into two branches, a *superior* or *ascending*, and an *inferior* or *descending* branch.

The *superior* or *ascending* branch, the superficial *temporal nerve*, turns round the back of the neck of the condyle, and ascends vertically between the articulation and the external auditory meatus: having become subcutaneous it divides into several filaments (*r*, *fig.* 285.), which may be traced up to the highest part of the temporal fossa.

During its course this nerve gives off a very remarkable anastomotic branch, which arises behind the neck of the condyle, and is reflected upon it so as to run forwards beneath the facial nerve, with which it is blended opposite to the posterior border of the masseter. This anastomotic branch is sometimes double. It may be regarded as one of the origins of the facial nerve, which increases considerably in size after having received it.

This branch is one of the principal communications between the facial nerve and the fifth nerve, and modern physiologists have justly attached great importance to it.

The ascending branch also gives off some plexiform branches to the temporo-maxillary articulation, and several filaments to the auditory meatus and the auricle. In the temporal region it anastomoses with a very small filament, which is derived from the deep temporal nerve, and which perforates the temporal fascia.*

It accompanies the temporal artery, for which it forms a sort of plexus, and then divides into cutaneous filaments, which reach the crown of the head.

The *inferior*, *descending*, or *auricular* branch is as large as the preceding; it forms a plexus around the internal maxillary artery, behind the condyle, and sometimes presents small ganglia; it divides into several branches, some of which pass through the parotid gland and are distributed to the lobe of the ear, whilst the others anastomose with some filaments of the auricularis mag-

* [This perforating cutaneous filament is one of the temporal filaments of the orbital branch of the superior maxillary nerve (see notes, pp. 1114. 1119.).]

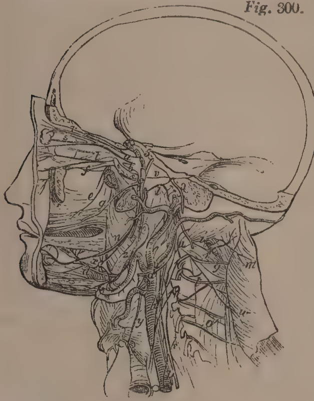
nus nerve derived from the cervical plexus. One of these branches joins the dental nerve, before that nerve enters the dental canal; another branch terminates in the temporo-maxillary articulation.

The Terminal Branches of the Inferior Maxillary Nerve.

The Lingual Nerve.

The *lingual* or *gustatory nerve* (*n*, *figs.* 298. 300; *n n'*, *fig.* 301.) passes downwards and forwards: it is at first situated between the external pterygoid muscle and the pharynx, but it soon passes between the two pterygoids (*fig.* 300.), then between the internal pterygoid and the ramus of the lower jaw (*fig.* 298.), and then runs forwards along the upper border of the submaxillary gland, between it and the buccal mucous membrane, and above the mylo-hyoid muscle; it then passes beneath the sublingual gland, which it crosses, to pass to its inner side and, accompanied by the Warthonian duct, which lies to its inner side and crosses it at a very acute angle, it gains the corresponding border of the tongue, and ramifies in the substance of that organ.

Fig. 300.



During its passage between the two pterygoids the lingual nerve is joined by that branch of the facial nerve which is known as the *chorda tympani* (*x*, *fig.* 298.), and which unites to it behind, forming a very acute angle opening upwards; this branch of the facial, which may be regarded as one of the roots of the lingual, remains in contact with that nerve for some time, and is at last blended with it.

The lingual nerve also receives, sometimes before, and sometimes after being joined by the chorda tympani, a very considerable anastomotic branch from the inferior dental: this branch is rarely wanting.

After receiving these two branches, the lingual nerve becomes considerably increased in size, and during its course gives off several filaments to the tonsils, the mucous membrane of the cheeks and the gums.

Opposite the submaxillary gland, the lingual nerve presents a very remarkable ganglion, generally described as the *submaxillary ganglion* (situated behind *x*, *fig.* 300.); the trunk of the nerve does not enter into its formation, but it appears to be formed only by its inferior filaments. It has been gratuitously supposed that this ganglion is formed exclusively by the chorda tympani, which, according to such a view, after running in mere contact with the lingual nerve, becomes detached from it (opposite *n*) to enter the ganglion (*x*); we have stated that there was equally little reason to suppose that the chorda tympani was the continuation of the cranial branch of the vidian. The submaxillary ganglion, the size of which is very variable, gives off a great number of filaments, most of which are distributed to the submaxillary gland; one of these filaments accompanies the Warthonian duct.

Having reached the sublingual gland, the lingual nerve supplies that gland with a great number of filaments, which dip into it and form a plexus of very delicate meshes.

In the tongue, the lingual nerve is situated at the lateral border of that organ, and on a plane above that of the hypoglossal nerve, with which it communicates by an anastomotic branch, forming a loop. It becomes gradually diminished in size by giving off a very numerous series of filaments

(*n'*, *fig.* 301.), which turn round the border of the tongue, pass forwards and upwards, perforate the muscles of that organ, and spread out into pencils, the filaments of which may be traced into the papillæ of the mucous membrane. The nerve, reduced to a single filament, terminates at the point of the tongue.

The Inferior Dental Nerve.

The *inferior dental nerve* (*m*, *fig.* 298.), larger * than the lingual, descends with it, at first between the two pterygoid muscles, and then between the internal pterygoid and the ramus of the lower jaw: in this situation it is kept in contact with the bone by a layer of fibrous tissue, which is improperly called the internal ligament of the temporo-maxillary articulation, and which separates the nerve from the lingual nerve and the internal pterygoid muscle; it soon enters the dental canal, which it traverses (*m*) throughout its entire extent, accompanied by the inferior dental artery, and protected by a fibrous canal; during its course it supplies the molar and the bicuspid teeth, giving a twig to each prong, and having reached the mental foramen, divides into a *mental* and an *incisor* branch.

The myloid branch. As it enters the inferior dental canal, the nerve gives off a small branch, the *myloid branch* (*z*, *fig.* 300.), which arises from its posterior border, opposite the corresponding artery, is received into a furrow upon the inner surface of the ramus of the jaw, against which it is retained by a layer of fibrous tissue, and then, emerging from this furrow, passes upon the upper surface of the mylo-hyoid muscle, in which it ramifies. A great number of filaments from the myloid nerve enter the anterior belly of the digastric muscle. †

The *mental branch* (*t*, *fig.* 285.), the continuation of the inferior dental nerve, as far as size is concerned, passes through the mental foramen, and expands into diverging filaments, which are distributed in reference to the lower lip in the same way as the infra-orbital branch is to the upper lip. These filaments interlace with the facial nerve, and form with it a sort of *mental* plexus; they are intended for the skin and the mucous membrane of the lower lip: most of them pass to the free border of that lip.

The *incisor dental branch*, which is extremely small, continues in the original course of the inferior dental nerve, and subdivides to supply the canine and two corresponding incisor teeth.

The inferior dental nerve represents in the lower jaw the infra-orbital portion of the superior maxillary nerve in the upper jaw.

The Otic Ganglion.

I cannot terminate the description of the inferior maxillary nerve, without noticing a ganglion recently described by Arnold, under the name of the *otic ganglion*, which he compares to the ophthalmic ganglion, and which has served him as the basis of an ingenious theory respecting the nerves of the head. The following is the position of the ganglion, as indicated by Arnold: "The otic ganglion is situated (behind *l*, *fig.* 299.) immediately below the foramen ovale, on the inner side of the third or inferior maxillary division (*c*) of the fifth nerve, a little above the origin of the superficial temporal or auricular nerve (auriculo-temporal), at the spot where the inferior maxillary nerve gives off from its external surface the deep temporal and buccal nerves, and where the small root of the fifth unites intimately with the large root. On the inner side, this ganglion is covered by the cartilaginous portion of the Eustachian tube, and by the origin of the external peristaphyline (*circumflexus palati*) muscle; behind, it is in contact with the middle meningeal artery. Its external surface rests upon the inner side of the inferior maxillary nerve."

* I have observed that this nerve was much smaller in old than in young subjects.

† [Filaments are also given to the sub-maxillary gland; according to Ellis, some branches pass through the mylo-hyoid muscle and enter the genio-hyoid; and it is stated by Alcock that a branch reaches the depressor labii inferioris.]

There can be no doubt, that in the situation indicated by Arnold, there is a thin and not very well defined layer of reddish, pulpy tissue, placed upon the inner side of the internal pterygoid nerve, and which presents the chief characters of ganglionic tissue; for it is traversed by nervous filaments, which proceed from it as from a centre, and run in various directions.

Its connexions with the inferior maxillary nerve are effected by its direct adhesion to that nerve, which adhesion, according to Arnold, takes place by means of several very short nervous filaments (*short root*), which appear to come from the small root of the fifth pair; and also by its adhesion to the internal pterygoid nerve, so that at first sight the ganglion would appear to originate from that nerve, or the nerve from the ganglion.

The otic ganglion is also connected with the glosso-pharyngeal by means of a filament, which Arnold describes under the name of the *small superficial petrosal nerve* to distinguish it from the great superficial petrosal, or cranial branch of the vidian. This filament, which proceeds from *the nerve of Jacobson*, or tympanic branch of the glosso-pharyngeal, is compared by Arnold to the *long root* of the ophthalmic ganglion: it passes out of the cavity of the tympanum by a special canal, in front of the hiatus Fallopii, runs forwards and outwards (from 7 towards *c*, *fig.* 296.), emerges from the cranium through a special foramen between the petrous portion of the temporal bone and the spinous process of the sphenoid, and proceeds (above *l*, *fig.* 300.) to enter the otic ganglion.* Arnold admits a third root for the otic ganglion, namely, a soft root which he traces from the nervous plexus that surrounds the middle meningeal artery, and is derived from the great sympathetic.

The preceding filaments may be regarded as the filaments of origin of the otic ganglion.†

The branches which proceed from the otic ganglion. The principal filament from the otic ganglion runs backwards and upwards towards the canal which contains the internal muscle of the malleus, and is lost in that muscle. This twig must be carefully distinguished from the small superficial petrosal nerve, which is placed above it. Some other filaments join the auriculo-temporal nerve, which generally arises by two roots.

Lastly, the otic ganglion sends off a twig to the circumflexus palati muscle.

The Sixth Pair, or External Motor Nerves of the Eyes.

The very simple distribution of the external motor nerve of the eye, or sixth cranial nerve, contrasts strongly with that of the fifth nerve; it arises from the furrow between the pons Varolii and the medulla oblongata, immediately forms two fasciculi or roots, a large and a small, which unite in the cavernous sinus; they pass vertically upwards, perforate the dura mater (*b*, *fig.* 296.) at the side of the basilar groove by one or two openings, to the inner side of and below the fifth nerve, gain the apex of the petrous portion of the temporal bone, over which they turn, and then pass horizontally forwards to enter the cavernous sinus. During the course of the nerve through that sinus, it rests upon its lower wall, crosses (above 6, *fig.* 301.) on the outer side of the vertical portion of the internal carotid artery, around which it turns, and then runs along its horizontal portion. The sixth nerve forms a most important anastomosis, on account of which it was for a long time regarded as

* This small superficial petrosal nerve is very distinct from the great superficial petrosal nerve, being situated in front of and parallel to that nerve. In a subject which I dissected in 1826, I found this small nerve presenting the following peculiarity: — it had a well marked nodule or ganglion, which gave off a filament to the middle meningeal artery, and some small twigs which appeared to me to be lost in the substance of the sphenoid bone; but I did not discover the connexions of this nerve.

† Arnold admits an indirect communication between the otic ganglion and the acoustic nerve through the intervention of the facial nerve. The existence of this communication appears to me very doubtful, as well as the communication of the otic ganglion with the great sympathetic, by means of the twigs on the middle meningeal artery.

the origin of the great sympathetic. As it crosses the internal carotid in the cavernous sinus, it communicates by one or two filaments with the superior cervical ganglion. It also communicates at the same point with the ophthalmic division of the fifth nerve.

Lastly, it enters the orbit through the widest part of the sphenoidal fissure, passes through the fibrous ring which is common to it and to the inferior division of the common motor nerve, crosses at an acute angle beneath the ophthalmic nerve, and gains the inner surface of the external rectus, and penetrates that muscle after having expanded into a pencil of very delicate filaments.

We shall again advert to the communication between this nerve and the superior cervical ganglion.

The Seventh Pair of Nerves.

The Portio Dura, or the Facial Nerve.

We have already traced the *facial nerve*, or the *portio dura of the seventh*, from its origin to the internal auditory meatus, which it enters together with the auditory nerve (7, *fig.* 296.), which nerve lies below and behind the facial, and forms a groove for its reception. Having reached the bottom of the internal auditory meatus, this nerve follows the long course of the facial canal *, or *aqueduct of Fallopius*, a winding passage which is formed in the petrous portion of the temporal bone, and which opens by one end into the internal auditory meatus, and by the other upon the lower surface of the pars petrosa at the stylo-mastoid foramen.

The facial nerve traverses this canal, which is exclusively appropriated to it; it is at first directed outwards (*n*, *fig.* 296.), and after proceeding for about a line bends suddenly, and runs backwards, in the substance of the internal wall of the cavity of the tympanum, above the fenestra ovalis. Having reached the back of the tympanum, it forms another bend, and passes vertically downwards (*o*, *figs.* 298. 300.) to the stylo-mastoid foramen. It follows, therefore, that the facial nerve describes two curves, like the aqueduct of Fallopius, and is horizontal in its first two portions and vertical in the third.

On emerging from the stylo-mastoid foramen, the facial nerve runs forwards in the substance of the parotid gland, and after a course of about five or six lines divides into two terminal branches, the *temporo-facial* (*g*, *fig.* 285.) and the *cervico-facial* (*f*), which expand into a great number of diverging filaments, and cover the temples, the whole of the face, and the upper part of the neck, with their radiations and anastomoses.

The facial nerve gives off and receives certain collateral branches before and others after its exit from the stylo-mastoid foramen.

The Collateral Branches of the Facial Nerve before its Exit from the Stylo-Mastoid Foramen.

In the *internal auditory meatus*, the facial nerve receives some twigs from the auditory, a remarkable anastomosis which deserves the attention of physiologists.

Opposite to the hiatus Fallopii, *i. e.* at the first bend formed by the Fallopian aqueduct, the facial nerve is joined by the cranial branch of the vidian or the great superficial petrosal nerve (*v*, *figs.* 296. 300.). According to MM. Ribes, Hippolyte Cloquet, and Hirzel, this branch is applied to the facial nerve, but does not anastomose with it, and is detached from it lower down to constitute the chorda tympani nerve; and as the cranial branch of the

* For what purpose is this long course within the petrous portion of the temporal bone? Those physiologists who believe the facial nerve to be of a mixed nature, that is, both sensory and motor, have laid great stress upon this point, which they conceive to be favourable to their views; but there is not the slightest shadow of a proof that the facial nerve possesses these two properties.

vidian arises from the spheno-palatine ganglion, and the chorda tympani is supposed to enter the sub-maxillary ganglion, it is seen that, according to this view, the cranial branch of the vidian and the chorda tympani, which is regarded as its prolongation, would establish a communication between the spheno-palatine and sub-maxillary ganglia. It is by no means proved, however, that the chorda tympani enters the sub-maxillary ganglion; and again the supposed connexion between the cranial branch of the vidian and the chorda tympani is opposed to facts. The cranial branch of the vidian and the facial nerves, indeed, are not in mere juxtaposition, but anastomose and are blended with each other, and the chorda tympani has no sort of relation to the former of these nerves. This independence of the branch of the vidian nerve and the chorda tympani can be most clearly seen when the parts have been macerated in diluted nitric acid.*

If an explanation must be given of this remarkable anastomosis between the vidian and facial nerves, I would say, that the cranial branch of the vidian may be regarded as a remote origin or a reinforcing branch of the facial nerve.

The facial nerve, according to Soemmerring and those who have followed him, gives off a twig to the internal muscle of the malleus, and another to the small muscle of the stapes; but, in the first place, the existence of a stapedius muscle is doubtful, and consequently the existence of a corresponding nervous twig must also be so: and, in the second place, the internal muscle of the malleus is not supplied from the facial nerve, but from the inferior maxillary division of the fifth nerve, and more especially from that pulpy, reddish tissue named by Arnold the otic ganglion.

Before leaving the aqueduct of Fallopius, the facial nerve (*n*, *fig.* 296.) gives a remarkable filament, named the *chorda tympani*, which pursues a recurrent course (*y*), from below upwards in a peculiar canal, parallel to the aqueduct of Fallopius, enters the cavity of the tympanum through an opening to the inner side of and behind the attachment of the membrana tympani, passes downwards and forwards through the cavity of the tympanum, between the handle of the malleus and the vertical ramus of the incus, and emerging from that cavity (*x*, *fig.* 298.), not through the Glasserian fissure, but through a special opening already described (see ORGAN OF HEARING — *Cavity of the Tympanum*), is applied to the lingual nerve (*n*), of which it may be regarded as a late origin, or reinforcing branch.

The facial nerve also receives in the aqueduct of Fallopius, opposite to where it gives off the chorda tympani, a very remarkable branch, from the pneumogastric nerve, which Arnold has named the *auricular branch of the pneumogastric.*

The Collateral Branches of the Facial Nerve, after its exit from the Stylo-mastoid Foramen.

Before its terminal division, the facial nerve gives off two branches: the *posterior auricular* and the *styloid.* I have never seen any parotid branch properly so called.

The *posterior auricular*, which would be better named the *auriculo-occipital*, comes off from the nerve within the stylo-mastoid foramen, and is immediately applied against the mastoid process, turning round over its anterior and then its outer surface †; as it lies in front of the mastoid process, it anastomoses

* Arnold has pointed out, at the junction of the cranial branch of the vidian with the facial nerve, a *gangliform swelling*, which he regards as a transition between a gangliform enlargement and a true ganglion; from this swelling, which he compares to the ganglia of the posterior roots of the spinal nerves, he says a filament is given off to anastomose with the auditory nerve at the bottom of the internal auditory meatus. I have not been fortunate enough to discover this filament; nor have I ever seen any gangliform appearance at the junction of the vidian and facial nerves.

† This little nerve is lodged in the furrow between the mastoid and vaginal processes (see OSTEOLOGY, p. 58.).

with a remarkable twig from the deep auricular branch of the auricularis magnus from the cervical plexus *; after this, it divides into two branches: an *ascending* or *auricular* branch (*m*, *fig.* 299.), properly so called, which having first supplied then perforates the posterior auricular muscle, turns round the auricle, and terminates in the superior auricular muscle; and a *horizontal* or *occipital* branch, (*v*, *fig.* 285.), which is larger and forms the continuation of the nerve; it passes immediately beneath the posterior auricular muscle, to which it gives some filaments, then runs exactly along the superior semicircular line of the occipital bone, and terminates by giving off from its upper side a series of small filaments, which are lost in the occipital portion of the occipito-frontalis: they can be traced as far as the median line, but none of them are distributed to the skin.

The *styloid branch* arises from the back of the facial nerve, at its exit from the stylo-mastoid foramen, and enters the stylo-hyoid muscle, after having run along its upper border.

The *posterior mastoid* or *digastric branch* often arises by a common trunk with the preceding, enters the posterior belly of the digastric muscle, and sends off an anastomotic twig to the glosso-pharyngeal nerve.

The Terminal Branches of the Facial Nerve.

The Temporo-facial Nerve.

The *temporo-facial nerve* (*g*, *fig.* 285.) passes upwards and forwards in the substance of the parotid, forming, with the trunk of the facial nerve, an arch having its concavity turned upwards; it crosses the neck of the condyle of the lower jaw, and receives in this situation, by its deep surface, one or sometimes two branches from the auriculo-temporal nerve, a branch of the inferior maxillary. This anastomotic branch establishes a very important connexion between the fifth and facial nerves.

The temporo-facial nerve, which is flattened and plexiform where it is joined by the branch from the fifth, afterwards expands into a number of filaments which anastomose with each other, so as to form arches, from the convexity of which a number of diverging filaments of unequal size proceed like rays, and cover the whole space comprised between a vertical line drawn in front of the ear, and a horizontal line corresponding to the base of the nose.

All these branches, which anastomose several times with each other, and form a succession of arches somewhat resembling those of the mesenteric arteries, may be divided into the *temporal*, the *orbital*, and the *infra-orbital* or *buccal* branches.

The *temporal branches* ascend, cross over the zygomatic arch at right angles, and cover with their ramifications the whole of the temporal and frontal regions, anastomosing with filaments from the frontal branch of the first [from the orbital branch of the second], and from the auriculo-temporal branch of the third division of the fifth nerve.

All these branches lie between the skin and the temporal aponeuroses: some of them supply the skin, but the majority are distributed to the frontal portion of the occipito-frontalis muscle, below which they are situated, and may be traced as far as the median line.

The *orbital branches* may be divided into the *superior palpebral*, which are remarkably long, and pass beneath the orbicularis palpebrarum to ramify in that muscle and the corrugator supercilii. Several of these anastomose with twigs from the supra-orbital nerve; the *middle palpebral branches*, which gain the outer angle of the eyelids, and are distributed between the upper and lower eyelids, and the *superior palpebral branches*, which are generally named the *malar* branches; they pass horizontally forwards, opposite to the lower part of

* [It is also joined, according to Arnold, by a filament from the auricular branch of the pneumogastric (see note, p. 1132.).]

the orbicularis palpebrarum, and are reflected upwards, to enter the substance of the lower eyelid, between the palpebral aponeurosis and the palpebral portion of the orbicularis, in which they terminate.

They may be traced as far as the free border of the tarsal cartilage where they anastomose with each other.

The *infra-orbital* or *buccal branches* of the temporo-facial are given off from one or two large branches which accompany the Stenonian duct; they expand into a great number of filaments, which may be divided into a *superficial* and a *deep set:* the *superficial* branches run beneath the skin, and above the orbicularis oris, the two zygomatici, and the levator labii superioris, all of which they supply; there can be no doubt that they also give cutaneous filaments; these are very small, and very long, and may be followed as far as the hair follicles in the upper lip; some of these superficial branches reach the lower eyelid, several accompany the facial and angular veins, anastomose with twigs from the infra-trochlear branch of the nasal nerve, and ascend as far as the pyramidalis nasi in which they terminate.

The *deep branches* pass beneath the levator labii superioris, send off numerous filaments to that and the levator anguli oris, and form, together with the terminal divisions of the infra-orbital branch of the superior maxillary, a very remarkable plexus, which may be called the infra-orbital.

This plexus is formed by the interlacement of the radiating branehes of the facial nerve with those of the infra-orbital branch of the superior maxillary division of the fifth nerve. Now, as the facial nerve radiates from without inwards, and the infra-orbital from above downwards, it follows that the branches of these two nerves meet each other at right angles. This arrangement can be rendered more evident by pulling the two sets of nerves in the direction of their length. Most of these branches interlace without anastomosing, and proceed directly to their destination. The destination of the facial nerve is evidently rather to the muscles than to the skin; that of the infra-orbital branch of the fifth nerve is rather to the skin and mucous membrane than to the muscles; nevertheless, it cannot be doubted that the facial nerve supplies some cutaneous filaments, and that the fifth nerve gives some twigs to the muscles. Besides, there are some undoubted anastomoses between these two nerves. The facial also communicates very freely with the buccal nerve, a branch of the inferior maxillary.

The infra-orbital branches of the temporo-facial nerve supply the two zygomatics, the levator labii superioris, the levator labii superioris alæque nasi, the depressor alæ nasi, the transversalis nasi, the levator anguli oris, and the orbicularis oris. I would also point out a very remarkable branch, which enters the substance of the ala of the nose, and appears to be intended for that sort of sphincter muscle found in the cutaneous fold of the alæ. This branch anastomoses with the naso-lobar branch of the internal nasal nerve.

The infra-orbital branches of the fifth nerve are distinguished from the infra-orbital branches of the facial nerve, — by their direction; by being more deeply seated; by being much larger; and by being arranged in successive layers, which are three in number, a subcutaneous, a submucous, and a muscular: this last set perforates the orbicularis oris, in which some filaments appear to terminate. Among the infra-orbital branches of the fifth nerve, there is one which may be called the *nerve of the sub-septum*, which runs on the side of the median line, as far as the tip of the nose, where it terminates. Lastly the infra-orbital branches of the fifth give a dorsal branch for the nose, and two ascending palpebral branches, which can be easily distinguished from the palpebral branches of the facial nerve.

The Cervico-facial Nerve.

The *cervico-facial nerve* (*f*, *fig.* 285.), which is smaller than the temporo-facial, follows the original course of the facial nerve, and like it runs downwards and forwards in the parotid gland; opposite to the angle of the lower

jaw it divides into three or four branches which subdivide into secondary branches, which may be arranged into the *buccal*, *mental*, and *cervical* sets.

The *buccal branches* run horizontally forwards in front of the masseter, to which they give off some small filaments, and then anastomose with each other and with the infra-orbital branches of the temporo-facial nerve. A very beautiful anastomosis is found between the buccal branch of the inferior maxillary, and one of these buccal branches of the cervico-facial nerve: we have already pointed out a similar anastomosis between an infra-orbital branch of the temporo-facial and this same buccal branch of the inferior maxillary.

The *mental branches* are intended for the lower lip. They are reflected upwards so as to describe an arch having its concavity directed upwards; they are at first situated beneath the platysma myoides, then pass beneath the triangularis oris, and form with the mental branch of the inferior maxillary division of the fifth nerve an interlacement or mental plexus, which has a close analogy with the interlacement of the infra-orbital branches of the facial with those of the superior maxillary division of the fifth nerve, but is less complicated.

Thus, the mental branches of the facial nerve are more superficial than those of the fifth, and their filaments are smaller; the radiating branches of the facial nerve run at first forwards and then upwards, whilst those of the fifth nerve run directly upwards. The mental branches of the facial nerve perforate the quadratus menti and the orbicularis oris, to which muscles they are almost entirely distributed; they also send several long and slender filaments to the point of the chin, some of which are cutaneous. The mental branches of the fifth nerve are chiefly situated between the muscles and the mucous membrane, to which latter they are distributed, more especially to the free borders of the lower lip.

The *cervical branches* of the cervico-facial run forward in the suprahyoid region, beneath the platysma, and, describing arches with their concavities turned upwards, they pass upwards and forwards to terminate near the chin. Among these branches, there is one which passes vertically downwards to anastomose with the superficial cervical nerve of the cervical plexus.

The cervical branches of the facial nerve are separated from the cervical branches of the cervical plexus by the platysma, and they are all distributed to that muscle and the levator labii superioris.

Summary. The facial nerve supplies all the cutaneous muscles of the cranium and of the face, and therefore section and compression of this nerve cause complete paralysis of these muscles: it is the nerve of expression, or the respiratory nerve of the face (*Bell*); it also evidently gives off some cutaneous filaments, especially near the commissure of the lips, and this may explain the numbness which I have known to occur in individuals affected with hemiplegia of the face; lastly, it furnishes a great number of anastomotic filaments (whence it has been called the small sympathetic); these are given to the branches of the cervical plexus, to the auditory nerve, to the pneumogastric, and more especially to the fifth nerve.

The anastomoses of the facial with the fifth nerve merit special notice; they are effected with the frontal and nasal nerves of the ophthalmic or first division of the fifth; with the superior maxillary or second division by means of the infra-orbital nerves and the cranial branch of the vidian; which latter I even regard as one of the origins of the facial nerve; and with the inferior maxillary or third division of the fifth by means of the mental nerve, the buccal nerve, and more especially the auriculo-temporal nerve. The branch given by the auriculo-temporal to the facial nerve may be regarded as one of the origins of the last-mentioned nerve.

Notwithstanding these numerous anastomoses, the facial nerve and the fifth nerve cannot supply the place of each other. Anatomy shows no difference in the structure of these nerves, but a great difference in their distribution; the facial nerve being intended for the muscles, whilst the fifth is distributed to the integuments and the organs of the senses.

Function. The facial is a nerve of motion. This fact may be deduced from its anatomical description no less than from physiological experiments and the effects of disease.

The Portio Mollis or the Auditory Nerve.

The *auditory nerve* (7, *figs.* 296. 301.), which we have already traced as far as the internal auditory meatus, enters that canal with the facial nerve, for which it forms a groove, and divides into two cords, which remain distinct throughout the whole extent of the passage, but continue in contact with each other, and at length pass through the foramina in the cribriform plate already described as existing at the bottom of the meatus (see OSTEOLOGY).

In order to understand the further distribution of the auditory nerve, the cribriform plate of the auditory meatus must be examined with the same attention as was devoted by Scarpa to the cribriform plate of the ethmoid, with which it has so many analogies. As the cribriform plate of the ethmoid presents a particular fissure for the passage of the ethmoidal branch of the ophthalmic nerve, so the cribriform plate of the internal auditory meatus presents a special opening for the passage of the facial nerve; and again, the auditory like the olfactory nerve seems as if it were pressed through the foramina of the cribriform plate to enter the internal ear.

Of the two terminal branches of the auditory nerve, the anterior is intended for the *cochlea*, the posterior for the *vestibule* and *semicircular canals.*

The *cochlear branch* turns spirally, like that part of the bottom of the auditory meatus to which it belongs, and which is called the tractus spiralis. It then turns upon itself, as observed by Valsalva, and presents somewhat of a ganglionic appearance. From this sort of enlargement the cochlear filaments proceed; those which belong to the first turn of the cochlea run along the surface of the modiolus; the others enter the canals of the modiolus, and are distributed on the second and the succeeding half turn at the summit of the cochlea. I have already described the very regular manner in which these filaments spread upon the spiral septum, the subdivision of each of them into two or three filaments which anastomose with each other like the ciliary nerves, and the gradual diminution in the length of these filaments from the base to the apex of the cochlea, so that if we suppose the spiral septum spread out, it might be compared to a harpsichord, the longest strings of which would be represented by the filaments at the base of the triangle formed by the septum, and the shortest by those at its apex (see INTERNAL EAR, p. 907.).

The *vestibular branch* divides into three parts, the largest of which enters the *utricle* and the *ampullæ* of the superior vertical and horizontal membranous canals, the middle-sized branch passes to the *sacculus*, and the smallest branch to the *ampulla* of the posterior or inferior vertical semicircular canal.

Function. The auditory nerve is exclusively the nerve of hearing.

THE EIGHTH PAIR OF NERVES.

The First Portion or Glosso-pharyngeal Nerve.

Dissection. Remove by a triangular section the posterior half of the border of the foramen lacerum posterius; carefully detach the jugular vein, in front of which the nerves are situated, examine the connexions of the glosso-pharyngeal with the pneumogastric and spinal accessory nerves.

The *glosso-pharyngeal nerve* (*pharyngo-glossal*), the *anterior portion of the eighth nerve* (8, *figs.* 296. 301.), the *ninth nerve of some authors*, is intended for the pharynx and the tongue.

Having arisen from the restiform body above and on a line with the pneumogastric,* by a series of roots which are continuous with the roots of that

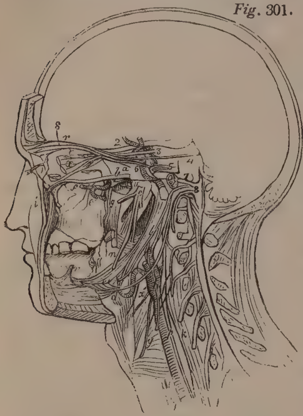
* Several modern physiologists, believing the glosso-pharyngeal to be a mixed nerve, sensory in its lingual portion, and motor in its pharyngeal, have, therefore, supposed it to have two

nerve, the glosso-pharyngeal emerges from the foramen lacerum posterius through a fibrous canal which is proper to it, and which is situated in front of the canal that is common to the pneumogastric and spinal accessory nerves; it is placed to the inner side of the internal jugular vein, from which it is separated by a cartilaginous and sometimes osseous lamina.

During its passage through this canal it presents a ganglionic enlargement, which was described by Andersh under the name of *ganglion petrosum*, and is now more generally known as the *ganglion of Andersh.*

This ganglion is situated in a depression on the petrous portion of the temporal bone (*receptaculum ganglii petrosi*); from it the nerve proceeds as a rounded cord, which descends vertically (*l*, *fig.* 301.) behind the styloid muscle in front of the internal carotid, then between the stylo-pharyngeus and the stylo-glossus, and passing forwards so as to describe a curve with its concavity turned upwards, runs in front of the posterior pillar of the fauces and behind the tonsil, and then passing beneath the hyo-glossus muscle (*z*), ramifies to enter the base of the tongue and supply the mucous membrane.

Fig. 301.



During this course it gives off the nerve of Jacobson, and an anastomotic twig to the facial nerve; it communicates with the spinal accessory and the pneumogastric; it gives off a muscular branch to the digastricus and stylo-pharyngeus, and it supplies some carotid filaments, and some pharyngeal and tonsillar branches.

The *nerve of Jacobson.* In order to facilitate the study of the course of this nerve, I shall first describe the canals through which it passes:—

Upon the ridge which separates the jugular fossa from the carotid canal, to the outer side of the aqueduct of the cochlea, is found an opening, which is the inferior orifice of the canal of Jacobson. This canal runs backwards and upwards into the substance of the internal wall of the cavity of the tympanum, in front of the fenestra rotunda; there it branches into three canals; one *descending*, which opens into the carotid canal; and two ascending canals, an anterior, which runs forwards and upwards, and opens into the groove for the great superficial petrosal or cranial branch of the vidian nerve, and a posterior, which at first ascends vertically behind the fenestra ovalis, then curves suddenly and becomes horizontal, and opens upon the upper surface of the pars petrosa in a groove parallel to and on the outer side of the groove for the cranial branch of the vidian nerve.

The nerve of Jacobson which comes off from the petrosal ganglion, or ganglion of Andersh, enters this canal. In one subject I found it to consist of two filaments, one from the pneumogastric, and the other from the glosso-pharyngeal.*

This nerve soon divides into three filaments corresponding to the three branches of the canal; the descending filament joins the carotid plexus; of the two ascending filaments, one anastomoses with the cranial branch of the vidian, or the great superficial petrosal nerve (*v*, *fig.* 300.), whilst the other constitutes the small superficial petrosal nerve, which reaches the upper surface of the

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distinct roots, — a larger, which is near the par vagum, and a smaller, which lies near the facial nerve; and from analogy they regard the former as the sensory, and the latter as the motor root.

* In another subject it was formed by the anastomosis of a twig from the auricular branch of the pneumogastric with a twig from the glosso-pharyngeal.

pars petrosa in front of the preceding, and terminates in the reddish tissue known as the otic ganglion.*

It follows, therefore, that the nerve of Jacobson connects the glosso-pharyngeal nerve with the superior maxillary division of the fifth nerve, (especially with the spheno-palatine ganglion through the intervention of the vidian nerve), with the otic ganglion of the inferior maxillary division, and with the superior cervical ganglion of the sympathetic.

The *anastomotic branch* to the *facial* nerve arises from the ganglion of Andersh immediately below the nerve of Jacobson; it runs downwards and outwards behind the styloid process, is then reflected upwards, so as to describe a loop with its concavity turned upwards, and anastomoses with the facial immediately after the exit of that nerve from the stylo-mastoid foramen. This branch appears to me to be the remaining trace of a considerable branch of the facial nerve, which I have seen partially supplying the place of the glosso-pharyngeal (see the TONGUE, Vol. I. p. 448.).

The *anastomosis of the glosso-pharyngeal with the spinal accessory and pneumogastric nerves.* Most commonly the glosso-pharyngeal runs along the pneumogastric, or more correctly along the anastomotic branch of the spinal accessory. Sometimes it is completely separated from these nerves, and merely communicates with them by means of its pharyngeal branches.

The *branch for the digastricus and stylo-hyoideus.* This branch comes off from the outer side of the nerve, and bifurcates; one of its divisions enters the posterior belly of the digastricus, and the other supplies the stylo-pharyngeus and stylo-hyoideus. It has already been stated that this branch anastomoses with the facial nerve in the digastric muscle.

The carotid filaments. These are very numerous; they descend along the internal carotid artery, and, having reached the point of bifurcation of the common carotid, anastomose with the carotid filaments of the superior cervical ganglion, and assist in forming the arterial plexus. I have not been able to trace them below the bifurcation of the common carotid. Some of these filaments are described as joining the cardiac nerves.

The pharyngeal branches. These are two or three in number; they anastomose with the pharyngeal branches of the pneumogastric to constitute the pharyngeal plexus. These branches evidently supply the middle and superior constrictors. The filaments for the latter muscle are reflected upwards upon the posterior surface of the pharynx.

The *tonsillar branches* are very numerous, and form a sort of plexus.

The lingual branches. After having given off the different branches above-mentioned, the glosso-pharyngeal, reduced to half its original size, enters the base of the tongue, and then ramifies; some of its lingual branches lie close beneath the mucous membrane; others traverse the upper layers of the muscular substance of the tongue to proceed to the mucous membrane, in front of the preceding branches; they are all intended for the mucous membrane; the internal branches proceed from without inwards at the side of the median line, whilst the external runs along the border of the tongue; I have never seen any filament terminating in the muscular fibres.

Function. From its distribution this nerve must be regarded as a motor nerve for the pharynx, and a sensory nerve for the base of the tongue.

* Arnold admits six filaments for the nerves of Jacobson, and consequently six small ducts as branches of the canal of Jacobson; these six filaments consist of the three described in the text above, and of a twig for the fenestra rotunda, one for the fenestra ovalis and one for the Eustachian tube. I have distinctly seen the twig for the fenestra ovalis, that is to say, a twig which reaches the margin of the fenestra ovalis, but cannot be traced any farther. I have also seen the twig which passes to the Eustachian tube; but I have not yet been able to find the twig for the fenestra rotunda.

The Second Portion of the Eighth Nerve, or the Pneumogastric Nerve.

Dissection. Lay open the back part of the foramen lacerum posterius, and afterwards examine the nerve in the different parts of its course successively.

The *pneumogastric nerve*, called also the vagus nerve, the *par vagum*, and the *tenth cranial nerve* of some modern authors, is the principal branch of the eighth nerve (8, *fig.* 301.), and is one of the most remarkable nerves in the body, both on account of the extent of its distribution, and of the importance of the organs supplied by it. It supplies branches, on the one hand, to the larynx, the lungs, and the heart; and, on the other, to the pharynx, the œsophagus, the stomach, and the solar plexus.

It has already been stated that this nerve arises from the upper part of the medulla oblongata, upon the restiform bodies, and in a line with the posterior roots of the spinal nerves; that its filaments of origin converge, and then unite at first into seven or eight fasciculi, and then into a single cord, which passes towards the foramen lacerum posterius, through which it emerges from the cranium. The pneumogastric nerve then runs vertically (*p. fig.* 301.) in the neck along the vertebral column, enters the thorax, runs along the œsophagus, with which it passes through the diaphragm, and terminates on the stomach and in the solar plexus.

We shall now proceed to examine this nerve whilst it is within the foramen lacerum posterius; as it is emerging from that foramen; and as it descends in the neck, in the thorax, and in the abdomen.

The Pneumogastric Nerve within the Foramen Lacerum Posterius.

At the foramen lacerum posterius the pnemogastric nerve passes through the same opening as the spinal accessory, which lies in contact with it; a fibrous, cartilaginous, or bony septum separates it from the glosso-pharyngeal, which lies in front of it; and another cartilaginous and often bony septum separates it from the internal jugular vein.

As it is passing through the foramen it presents a well-marked ganglionic structure; I would say rather a grey substance containing white nervous filaments, but without any observable swelling: hence, most anatomists have denied the existence of a ganglion at this spot.

To this ganglion, the *ganglion of the pneumogastric*, which may be compared to the Gasserian ganglion and to the intervertebral ganglia, the spinal accessory nerve is applied, and is connected with it by several very delicate filaments. I have already stated, that not unfrequently the highest roots of the spinal accessory nerve join the pneumogastric directly.

This ganglion gives off an anastomotic twig which enters the petrosal ganglion of the glosso-pharyngeal: I have not always found this filament; it also gives an *anastomotic branch* to the *facial nerve*, viz. the *auricular* branch of the *pneumogastric* of Arnold. This branch might be called the *branch of the jugular fossa;* it can be very well seen through the coats of the jugular vein, when that vessel is laid open. It runs along the anterior part of the jugular fossa, between it and the internal jugular vein, gives off an anastomotic twig to the nerve of Jacobson, enters the temporal bone through an opening in the jugular fossa, near the styloid process, and traverses a very short canal, which conducts it directly into the Fallopian aqueduct, in which it anastomoses with the facial nerve.*

* I have seen this branch, immediately after its origin, enter the sheath of the glosso-pharyngeal nerve, run along its ganglion, and then curve backwards to enter the jugular fossa. Arnold, who first described this anastomotic branch, represents it as divided into three filaments; an ascending, which anastomoses with the trunk of the facial nerve; a descending, which anastomoses with the posterior auricular branch of the same nerve, and a middle (*v. fig.* 299.), which ramifies upon the external auditory meatus.

The Pneumogastric Nerve, at its Exit from the Foramen Lacerum Posterius.

At its exit from the foramen lacerum posterius, the pneumogastric nerve presents the appearance of a plexiform cord, which is often accompanied by the grey matter of the ganglion for the space of about six lines or an inch. This plexiform cord has certain important connexions with the spinal accessory, the ninth or hypo-glossal nerve, the glosso-pharyngeal nerve, and the superior cervical ganglion.

It is joined by one of the branches of bifurcation of the spinal accessory, which we shall name the *internal* or *anastomotic branch* of the spinal accessory nerve; it becomes applied to the pneumogastric nerve, and may be distinguished from it for a considerable distance.

It also anastomoses with the hypo-glossal, at the point where it is crossed by that nerve, and at other times above that point. This anastomosis, moreover, is subject to great variety; sometimes it takes place by a very small filament, at other times by two or three twigs which form a sort of plexus.

It also anastomoses with the glosso-pharyngeal. The examination of this anastomosis, after the parts had been macerated in diluted nitric acid, enabled me to see that it is not, properly speaking, effected with the pneumogastric nerve, but with the anastomotic branch of the spinal accessory. Nothing can be more variable than these anastomoses, which are sometimes wanting on one side, and which are rather frequently effected through the intervention of the pharyngeal branches.

Lastly, the pneumogastric nerve communicates with the great sympathetic by one or two branches in man and some mammalia *; in the other classes of animals, the connexion is so intimate that it is altogether impossible to separate the pneumogastric from the superior cervical ganglion.

The connexions of the pneumogastric with the spinal accessory and superior cervical ganglion are two very important points in its anatomy.†

The Pneumogastric Nerve in the Neck.

In the cervical region, the pneumogastric nerve (*p*, *figs.* 298. 300, 301.) is situated in front of the vertebral column, the prævertebral muscles intervening between them, upon the side of the pharynx and œsophagus, and between the internal and then the common carotid which are on its inner side, and the jugular vein which is on its outer side; it is placed behind these vessels. It is closely applied to the carotid artery, being in the same sheath: it is separated from the cervical portion of the great sympathetic (*k*), which lies behind and to the outer side of it, by a great quantity of cellular tissue.

During this course it supplies the pharyngeal branch, the superior laryngeal nerve, and the cardiac filaments.

The pharyngeal branch or small pharyngeal nerve. This is often double, and is then distinguishable into a superior and an inferior; it comes off at a little distance from the foramen lacerum posterius, but its real origin is variable. In some cases it arises exclusively from the pneumogastric; at other times exclusively from the anastomotic branch of the spinal accessory, which, as already stated, does not become immediately blended with the pneumogastric; and it often arises both from the pneumogastric and the spinal accessory; lastly, the glosso-pharyngeal sometimes gives it a filament. It passes behind the internal carotid, gives off some carotid filaments, which join the more numerous twigs from the glosso-pharyngeal, and then anastomoses with the

* I have seen the pneumogastric nerve communicate with the great sympathetic, by filaments which come off at different heights from the cervical ganglion; two proceeded from the upper part of the superior cervical ganglion and then ascended; and two came from the lower part of the ganglion and descended to unite with the pneumogastric. I have met with a case in which the superior cervical ganglion was applied in its whole extent so closely to the pneumogastric that it was impossible to separate them.

† [The pneumogastric also receives a filament from the anastomotic loop of the first and second cervical nerves (see p. 1040.).]

ramifications of the glosso-pharyngeal, and with several large branches from the superior cervical ganglion, to form the *pharyngeal plexus*, which is one of the most remarkable plexuses in the body, and to which the varied and frequent nervous phenomena observed in that region must be referred. I shall recur to this plexus when describing the great sympathetic.

The superior laryngeal nerve (*x'*, *fig.* 301.). This is larger than the pharyngeal branch; it comes off from the inner side of the pneumogastric * as a rounded cord, which may be traced as high as the ganglion of the nerve; it passes downwards and inwards upon the side of the pharynx, behind the internal and external carotid arteries, which it crosses obliquely: it then turns forwards and inwards to gain the thyro-hyoid membrane, passing above the upper margin of the inferior constrictor of the pharynx; it runs for some time between the thyro-hyoid muscle and the thyro-hyoid membrane, perforates the latter at the side of the median line, and then enters the substance of the aryteno-epiglottid fold of mucous membrane, where it terminates by dividing into a great number of filaments.

During its course, it gives off a branch which is called the *external laryngeal* (*y*), and which I have seen arise directly from the pneumogastric itself; this branch communicates with the superior cervical ganglion by one or two filaments, and passes inwards and downwards upon the side of the larynx. It gives off one or two filaments, which anastomose with the superior cardiac nerve, behind the common carotid; Haller calls this communication between the external laryngeal and the great sympathetic — the *laryngeal plexus*.† The external laryngeal nerve also gives off several branches to the inferior constrictor of the pharynx, some to join the pharyngeal plexus, and some twigs to the thyroid gland; it then passes downwards and forwards between the inferior constrictor and the thyroid cartilage, and terminates by ramifying in the *crico-thyroid* muscle.

The *terminal expansion* of the superior laryngeal nerve is remarkable for its radiated arrangement; it is preceded by a flattening and thickening of the nerve. These expanded branches are all submucous, and may be arranged into the *anterior* or *epiglottid*, and the *posterior*.

The *anterior* or *epiglottid branches* are numerous and small; they run upon the margin, and on the fore part of the epiglottis; some of them reach its free extremity, others run between the fibro-cartilage of the epiglottis and the adipose tissue called the epiglottid gland; some of them perforate the epiglottis and ramify upon its posterior surface.

Among these anterior terminal filaments of the superior laryngeal nerve there is at least one which runs forwards under the mucous membrane covering the base of the tongue, and may be traced as far as the two rows of glands, which are arranged like the letter V. These filaments of the superior laryngeal nerve to the tongue are placed between the lingual branches of the right and left glosso-pharyngeal nerves, with which they have probably been confounded.

The *posterior* or *laryngeal filaments* contained in the aryteno-epiglottid fold are more numerous than the anterior branches; they are divided into the *mucous filaments*, the *arytenoid filament*, and the *anastomotic* or *descending filament*.

The *mucous filaments* are very numerous, and run upwards in the aryteno-epiglottid fold; some of them lie beneath the external and others beneath the internal layer of mucous membrane of this fold. They are intended

* It arises, therefore, on the opposite side to the anastomotic branch of the spinal accessory, which has not appeared to me to assist in its formation. I have seen the superior laryngeal arise by two roots, the larger of which came from the pneumogastric, whilst the other, which was very small, came from the glosso-pharyngeal. It appears to me that M. Bischoff's remarks concerning the origin of the superior laryngeal nerve on a level with the spinal accessory would apply to the pharyngeal branch of the pneumogastric.

† The superior laryngeal nerve (*x' fig.* 301.) forms a loop behind the carotids, like that formed by the hypo-glossal (*d*) in front of them, but lower down in the neck; that portion of the nerve which runs between the thyro-hyoid membrane and the thyro-hyoid muscle is extremely tortuous in some positions of the larynx.

for these two layers, and they terminate, for the most part, at the superior orifice of the larynx: their number explains the exquisite sensibility of this opening. Some of these mucous filaments may be traced into the substance of the arytenoid glands.

The *filament for the arytenoid muscle* is very liable to be confounded with the mucous filaments; it perforates the muscle from behind forwards, and is partly distributed to it and partly to the lining membrane of the larynx.

The *descending* or *anastomotic filament*, which is small, but of variable size, descends vertically, between the mucous membrane on the one hand, and the thyro- and crico-arytenoid muscles on the other, gains the posterior surface of the cricoid cartilage, and anastomoses upon it with the recurrent laryngeal nerve. This remarkable anastomosis was known to Galen.*

Thus the superior laryngeal nerve chiefly belongs to the mucous membrane of the larynx; but it gives branches to the arytenoid and crico-thyroid muscles: the branch for the latter comes from the external laryngeal division of this nerve.

The cardiac branches of the pneumogastric nerve in the neck. These vary both in number and size in different subjects, and even upon the two sides of the same body: they come off at different heights from the trunk of the pneumogastric; some of them, after a course of variable extent, join the superior cardiac nerves, either in the neck or in the thorax; the others pass directly to the cardiac plexus. The most remarkable of the cervical cardiac branches of the pneumogastric is that which comes off at the lower part of the neck, a little above the first rib; on the right side, it descends in front of the common carotid, and then in front of the brachio-cephalic artery, below which it anastomoses with the superior cardiac nerve. On the left side, it passes in front of the arch of the aorta, and anastomoses below that vessel with the superior cardiac nerve of that side. This branch sometimes goes directly to the cardiac plexus: it is sometimes double.

The Pneumogastric Nerve in the Thorax.

The *thoracic portion of the pneumogastric nerve* presents this peculiarity, that it differs remarkably on the right and left sides.

On the *right side*, the nerve (*p*, *fig.* 302.) enters the thorax, between the subclavian vein and artery: lower down, it passes behind the brachio-cephalic vein and the superior cava, and behind the phrenic nerve, at the side of the trachea, or rather in the groove between the trachea and œsophagus: it then passes behind the root of the lung, where it becomes flattened and enlarged, gives off a great number of branches, and appears to expand, in order to unite in a different arrangement. Below the root of the lung the right pneumogastric is always divided into two flattened branches, which run along the right side of the œsophagus, join together at a short distance from the diaphragm and pass behind the œsophagus, with which canal the common trunk enters the abdomen.

On the *left side*, the pneumogastric enters the thorax between the common carotid and the subclavian artery, in the triangular interval between those vessels, internal to and then behind the phrenic nerve, behind the brachio-cephalic vein, and to the left of the arch of the aorta †; it then passes behind the left bronchus, upon which it ramifies, and unites again into one or two branches, which pass in front of the œsophagus, and enter the abdomen with it.

In the thorax the pneumogastric gives off the *recurrent* or *inferior laryngeal nerve*, a *cardiac branch*, some *tracheal* and *œsophageal branches*, and branches to the anterior and posterior pulmonary plexuses.

* See note, p. 1136.

† The relation of the pneumogastric with the arch of the aorta explains the stretching and atrophy of this nerve in aneurisms of that portion of the vessel.

*The Recurrent or Inferior Laryngeal Nerve.**

This nerve (*r*, *fig.* 302.), so called on account of its reflected course, arises in front of the arch of the aorta on the left side, and of the subclavian artery on the right side: it is sometimes so large that it may be regarded as resulting from the bifurcation of the pneumogastric: it is reflected below and then behind the arch of the aorta on the left side, and the subclavian artery on the right, so as to form a loop or arch which has its concavity turned upwards, and which embraces the corresponding vessel. Having thus changed its course from a descending to an ascending one, the recurrent nerve enters the groove (*q*, *fig.* 301.) between the trachea and the œsophagus, and continues to ascend as high as the lower border of the inferior constrictor muscle of the pharynx; it then passes beneath that muscle, gives some filaments to it, runs behind the lesser cornu of the thyroid cartilage, and the crico-thyroid articulation, along the outer border of the posterior crico-arytenoid muscle, and terminates by ramifying in the muscles of the larynx.

During its course, the recurrent nerve gives off the following *collateral branches:* at the point of its reflection, it gives *several cardiac filaments*, which unite with the cardiac branches of the pneumogastric and great sympathetic. It is important to remark the intimate connexion which exists between the recurrent and the cardiac nerves: some very considerable anastomoses are almost always found between the superior and inferior cardiac nerves and the recurrent nerve: sometimes, indeed, the recurrent nerve forms the point at which the superior and middle cardiac nerves meet, and from which the inferior cardiac nerve is given off; the anastomoses between the recurrent and cardiac nerves sometimes form a true plexus.

The recurrent also gives *œsophageal branches*, which are much more numerous on the left than on the right side, so that the left recurrent nerve is much smaller in the larynx than the right nerve.

It also gives *tracheal branches*, which chiefly supply the posterior or membranous portion of that canal.

And, lastly, some *pharyngeal filaments*, all of which are destined for the inferior constrictor.

Excepting an anastomotic branch † for the superior laryngeal nerve, all of the *terminal branches* of the recurrent nerve are intended for the muscles of the larynx, and are thus distributed.

The *branch for the posterior crico-arytenoid* simply enters that muscle.

The *branch for the arytenoid* runs between the cricoid cartilage and the posterior crico-arytenoid muscle, and then ramifies in the arytenoid. It has already been stated that the last-named muscle is also supplied by the superior laryngeal nerve.

The *branch for the lateral crico-arytenoid and thyro-arytenoid* muscles is the true termination of the nerve; it passes on the outer side of these two muscular bundles, which, as formerly stated, constitute a single muscle in the human subject, and then enters them by very delicate filaments. I have distinctly seen a very delicate filament entering the crico-thyroid articulation.

After the pneumogastric has given off the recurrent nerve, and often before doing so, it furnishes, certain cardiac branches (*thoracic cardial*); these are subdivided into the *pericardial*, which run upon the outer surface of the pericardium, and are lost in it and in the cellular tissue which replaces the thymus; and into the *cardiac* branches, properly so called, which assist in the formation of the cardiac plexus.

* Those anatomists who regard the superior laryngeal nerve as a dependence of the spinal accessory believe that the inferior or recurrent laryngeal has a similar origin. I may repeat, and with still more reason, in reference to this nerve, what I have already stated in regard to the superior laryngeal, that it is impossible to demonstrate this continuity by dissection.

† [This anastomotic branch is superficial, and joins the descending filament from the superior laryngeal nerve, beneath the mucous membrane on the back of the larynx, and sometimes sends filaments into the arytenoid muscle; there is, generally, a second anastomosis between the superior and inferior laryngeal nerves on the side of the larynx, between the thyroid cartilage, and the thyro-arytenoid muscle.]

The pneumogastric also gives off certain *anterior pulmonary branches*, which run in front of the bronchus and of the pulmonary arteries and veins, cross obliquely over them, and then enter the substance of the lung, following the ramifications of the air tubes and bloodvessels: these pulmonary branches form what is called the *anterior pulmonary plexus.* I have seen several of them extend some considerable distance beneath the serous membrane, covering the inner surface of the lungs, before they entered the substance of those organs.

Behind the bronchus, and along the œsophagus, the pneumogastric nerve gives off posterior branches, consisting of a great number of *œsophageal branches*; of some *tracheal branches*, which principally supply the back or membranous portion of the trachea; and lastly, of *posterior pulmonary* or *bronchial branches*, which form the posterior *pulmonary plexus.*

The *posterior pulmonary plexus* is one of the most remarkable in the body; in it the pneumogastric nerve appears to be decomposed and expanded; there is a *right* and a *left pulmonary plexus.* The left is much larger than the right. The two plexuses are not independent of each other, but are connected by free anastomoses: this remarkable disposition establishes a community of function between the two nerves, and explains how one of them may supply the place of the other.

The pulmonary plexuses, which are completed by filaments from the great sympathetic, are situated behind the root of each lung, or, to speak more exactly, behind the bronchi (whence the name of *bronchial plexuses*). A few of the twigs emerging from them follow the pulmonary arteries, and appear to be lost in their coats; the others accompany the bronchi, some of them passing behind these canals, and others, being reflected forwards in the angles formed by their bifurcation, run along their anterior aspect, and terminate in their parietes. They may be traced as far as the ultimate ramifications of the air tubes. In large animals they can be easily seen entering the circular muscular fibres which surround the bronchial tubes.*

Below the pulmonary plexus, the pneumogastric merely gives off certain *œsophageal branches*, which surround the œsophagus in very great numbers. The right and left pneumogastric nerves anastomose with each other; but the communicating arches do not constitute those circular anastomoses, which have been so decidedly said to explain the pain caused by swallowing too large a morsel of food.

The Pneumogastric Nerve in the Abdomen.

The two pneumogastrics enter the abdomen with the œsophagus, the left nerve being in front and the right nerve behind that canal, and are distributed in the following manner:

The left nerve (*q*, *fig.* 302.), which is situated in front of the cardia, expands into a very great number of diverging filaments, some of which extend over the great cul-de-sac, and others over the anterior surface of the stomach; but the greater number gain the lesser curvature, and divide into two sets or groups; one of these leaves the lesser curvature, enters the gastro-hepatic omentum, is conducted by it to the transverse fissure of the liver, and enters that gland. The other group continues in the lesser curvature and may be traced as far as the duodenum.

The *right pneumogastric* (p'), situated behind the cardia, gives a much smaller number of branches to the stomach than the left, and joins the solar plexus (x), of which it may be regarded as one of the principal origins.

Summary of the distribution of the pneumogastric nerve. This nerve, it will be seen, has an extremely complicated distribution.

Within the *foramen lacerum posterius*, it anastomoses with the spinal ac-

* I have seen a nerve from the pulmonary plexus pass through some of the fibres of the œsophagus and ramify in the aorta.

cessory; with the facial nerve by means of the auricular branch of Arnold, or the branch of the jugular fossa; and with the nerve of Jacobson, and therefore with the glosso-pharyngeal nerve, by a twig from the same auricular branch.

At its exit from the foramen lacerum posterius, it anastomoses with a large branch of the spinal accessory; with the hypoglossal; with the glosso-pharyngeal; and with the superior cervical ganglion.

In the neck, it gives off the pharyngeal branch or small pharyngeal nerve the superior laryngeal nerve; and the superior cardiac branches of the pneumogastric.

In the thorax, it gives off the recurrent or inferior laryngeal nerve, which supplies some cardiac, œsophageal, pharyngeal, tracheal, and laryngeal branches; the inferior cardiac branches; and the pulmonary or bronchial branches.

In regard to its *structure*, the pneumogastric differs essentially from the other cerebro-spinal nerves, by the tenuity of its filaments and by their plexiform arrangement; and in both of these particulars, as well as in its distribution, it rather resembles the nerves of organic than those of animal life. In the description of the sympathetic, it will be seen how intimate are its relations with the pneumogastric nerve.

Functions of the pneumogastric. From the manner in which the pneumogastric is distributed, it follows, that it is a nerve both of sensation and of motion; for it supplies both the lining membrane of the respiratory and digestive passages, and the muscles and muscular coats of the same canals. Anatomy does not confirm the ingenious idea of Bischoff, that the pneumogastric is essentially a nerve of sensation, and that the portion which appears to be motor really belongs to the spinal accessory. Physiologists have studied the influence of the pneumogastric upon the larynx, the lungs, the heart, and the stomach in an infinite variety of ways; it appears from some experiments which I made upon this subject, that animals in which both pneumogasrics are simultaneously cut die almost immediately, when they are permitted to eat as much as they please; for, the contractility of the stomach and œsophagus being destroyed, the food, after having filled the stomach, distends the œsophagus, and passes from it into the larynx.

The Third Portion of the Eighth Nerve, or the Spinal Accessory Nerve of Willis.

We have already described the very remarkable origin of the spinal accessory nerve at the side of the cervical portion of the spinal cord, between the anterior and posterior roots of the spinal nerves, or rather immediately in front of the posterior roots, of which it appears to be a dependence: we particularly alluded to the arrangement of its highest filaments of origin, which come from the restiform bodies, and are continuous above with the roots of the pneumogastric, so that they sometimes even join that nerve, and below with the posterior roots of the spinal nerves.

Lastly, we have pointed out the varieties of its origin, its connexions with the first pair of cervical nerves, of which it almost always forms the posterior roots, its ascending course to the foramen magnum, through which it enters the cranium, and its exit from the skull by the foramen lacerum posterius.

It emerges from the foramen lacerum posterius, by an opening quite distinct from that for the glosso-pharyngeal, but common to itself and the pneumogastric nerve, behind which it is situated (8, *fig.* 301.). Whilst passing through the foramen lacerum posterius, it lies in contact with the ganglionic enlargement of the pneumogastric, and is connected with the ganglion by very delicate filaments, but it neither assists in the formation of that enlargement, nor is blended with it: at its exit from the foramen, it divides into two branches of equal size; an *internal* or *unastomotic*, which remains in contact

with the pneumogastric and is distributed with it, and a *muscular* branch * (cut off in *fig.* 301.).

The *anastomotic branch.* So intimately are the spinal accessory and pneumogastric nerves connected, or as it were fused together, that, up to the time of Willis, they were regarded as a single nerve. Willis first described the former, perhaps erroneously, as a separate nerve, under the name of *nervus accessorius ad par vagum, sive nervus spinalis.* In an excellent thesis, published in 1822*, M. Bischoff endeavoured to prove that the pneumogastric or par vagum and spinal accessory form but a single nerve, analogous to the spinal nerves in every respect; the spinal accessory being the nerve of motion, and the par vagum the nerve of sensation: " Nervus accessorius Willisii est nervus motorius, atque eandem habet rationem ad nervum vagum quam antica radix nervi spinalis ad posticam. Omnis motio cui vagus præesse videtur, ab illâ portione accessorii quæ ad vagum accidit, efficitur. Itaque vox quoque, sive musculorum laryngis et glottidis motus, ab accessorio pendet, et eo nomine accessorius nervus vocalis vocari potest."

To this view there are serious objections; in the first place, it is opposed to the law that the anterior roots preside over motion and the posterior over sensation. For the filaments of origin of the spinal accessory evidently form part of the posterior roots. Again, how can it be supposed that two nerves, which, like the spinal accessory and pneumogastric, arise so distinctly from the same line, that it is often difficult to separate them, can have such opposite functions!

Must we suppose that the law which regulates the anterior and posterior roots of the spinal nerves ceases to operate at the medulla oblongata? or must we admit, with Arnold, that there is not only a decussation of fibres from side to side in the medulla oblongata, but also from before backwards, so that the posterior columns of the medulla oblongata become the motor and the anterior the sensory? Still, even with this hypothesis, it must be remembered that the spinal accessory arises in part below the point where this antero-posterior decussation is supposed to exist. There evidently is an antero-posterior decussation opposite to the two anterior pyramids, as I have elsewhere stated (see MEDULLA OBLONGATA), but the other columns of the spinal cord are not concerned in it.

However this may be, the anastomotic branch of the spinal accessory may be traced, after maceration in dilute nitric acid, along the outer side of the pneumogastric. In a great number of cases, it evidently gives off the *small pharyngeal nerve*, which sometimes arises exclusively from the pneumogastric, and sometimes from both the pneumogastric and the spinal accessory. Scarpa declares the last arrangement to be constant and normal, and has represented it in several figures. In some subjects, the spinal accessory appears to have no share in the pharyngeal nerve, but then its anastomotic branch becomes applied to the pneumogastric below the origin of the pharyngeal nerve.

The anastomotic branch appears to me to have no share in the formation of the superior laryngeal nerve; and the same is the case with regard to the recurrent nerve. It appears to me anatomically impossible to prove the continuity of the spinal accessory and the superior and recurrent laryngeal nerves; I cannot, therefore, admit that the spinal accessory supplies the intrinsic muscles of the larynx.

The spinal accessory generally gives off a number of twigs which unite in front of the reddish and as it were ganglionic trunk of the pneumogastric nerve, to form a small plexus, which adheres to that nerve, and ends in the hypoglossal nerve.

* It is well to observe, that as they are passing through the foramen lacerum posterius, the pneumogastric and spinal accessory nerves adhere to the dura mater, in the same manner as the Gasserian ganglion.

† Nervi Accessorii Willisii Anatomia et Physiologia. Bischoff. Darmstadii.

Lastly, there are so many varieties in the mode of communication between the pneumogastric and spinal accessory nerves, that it is extremely difficult to refer them to any general law.

The muscular branch. This nerve descends vertically between the internal jugular vein and the occipital artery, beneath the digastric and stylo-hyoid muscles; it runs backwards and outwards (*t, figs.* 285. 298.), beneath the sterno-mastoid, generally perforating that muscle, but sometimes merely running along its deep surface, passes obliquely across the supra-clavicular triangle, and terminates in the deep surface of the trapezius.

Whilst perforating the sterno-mastoid, the spinal accessory nerve gives several branches to that muscle, which anastomose with others from the third cervical nerve, and from a sort of plexus within the muscle.

On emerging, somewhat reduced in size, from the sterno-mastoid, it receives a branch (*v, fig.* 298.), from the anastomosis, between the second and third cervical nerves, by which its size is greatly increased: it assists in the formation of the cervical plexus, and sometimes of the posterior auricular nerve.

Having reached the anterior surface of the trapezius, it receives two considerable branches, derived from the third, fourth, and fifth cervical nerves, which appear to me to reinforce it. It gives off ascending filaments to the occipital portion of the muscle; and descending filaments, which continue in the original course of the nerve in front of the muscle, approach its scapular attachments, and may be traced down to its inferior angle. The muscular branch of the spinal accessory belongs exclusively to the sterno-mastoid and trapezius muscles. It has been incorrectly stated, that it supplies other muscles, such as the rhomboidei, the levator anguli scapulæ, the complexus, the splenius, and the subscapularis, and that it is also distributed to the skin.

In front of or rather in the substance of the trapezius, the spinal accessory anastomoses with the posterior branches of the spinal nerves.

Summary. The spinal accessory gives branches to the sterno-mastoid, the trapezius, and the pharynx; it is believed also to send some to the larynx by means of its anastomotic branch with the pneumogastric. It communicates with the second, third, fourth, and fifth cervical nerves.

Function. In reference to its muscular branch, Sir C. Bell has classed the spinal accessory among the respiratory nerves, under the name of the *superior respiratory nerve of the trunk;* for, accouring to that anatomist, it arises from the lateral column of the cord, between the anterior and posterior columns.

With regard to the anastomotic branch of this nerve which becomes blended with the par vagum, M. Bischoff lays down the following proposition (page 95.): " Nervum accessorium nimirum nervum motorium esse, ideoque in partes vagi adscisci, ut motus, quibus hic qui sensificus tantummodo nervus est, præesse videatur, ipse perficiat: eundem ergo præesse motibus quoque musculorum laryngis, indeque nervum esse vocalem." This idea, which was suggested to him by theory, he endeavoured to confirm by experiment. The section of all the roots of the spinal accessory proved to be very difficult; but after many fruitless attempts, he at length succeeded in dividing them on both sides. The hoarseness produced by section of all the roots of the right side gradually increased as he divided those of the left side, and when all had been cut the natural voice of the animal was changed to a very hoarse sound, which could not be called the voice.

I have already said that anatomy affords no proof that the laryngeal nerves are derived from the spinal accessory; nor does it show that the muscular fibres of the bronchi, œsophagus, and stomach, receive their filaments from it.

The Ninth Pair, or Hypo-glossal Nerves.

The *hypo-glossal,* or great hypo-glossal nerve, the ninth cranial, or the twelfth nerve of some modern authors, arises on each side from the furrow between

the olivary and pyramidal bodies, by a row of filaments collected into two very distinct fasciculi, which proceed to the anterior condyloid foramen (*q*, *fig.* 296.), perforate the dura mater separately, and join together so as to emerge from the canal in the form of a rounded cord.*

After leaving the anterior condyloid canal, the hypo-glossal nerve (*d*, *fig.* 301.) descends vertically between the internal carotid, which is on its inner side, and the internal jugular on its outer side. At first it lies behind the pneumogastric (8 to *p*), it then crosses very obliquely over the outer side, and lower down it gets in front of that nerve, around which therefore it describes a semi-spiral.

Having arrived below the posterior belly of the digastric muscle, the hypo-glossal changes its direction and runs forwards and downwards (*d*, *fig.* 300.), crossing in front of the internal and external carotids [and hooking beneath the occipital artery], it is then reflected upwards to reach the under surface of the tongue (*d* near *x*), and thus describes a loop having the concavity turned upwards, parallel to and below the digastricus, and almost ten lines above the os hyoides.

Relations. It is situated deeply in its vertical portion, where it runs along the vertebral column, becomes superficial in its middle portion (*d*, *fig.* 298.), where it is merely separated from the skin by the platysma and the prominence of the sterno-mastoid, and again becomes deep-seated anteriorly, where it rests on the hyo-glossus muscle, and is covered by the anterior belly of the digastricus and by the stylo-hyoideus, and then by the submaxillary gland and the mylo-hyoideus, after which it enters the genio-glossus, and is lost in the substance of the tongue.

The relations of the hypo-glossal nerve and the lingual artery are worthy of remark. The nerve is at first parallel to and above the artery, is soon separated from it by the hyo-glossus, and then rejoins it in front of that muscle. In the substance of the tongue, the artery lies to the outer side of the genio-glossus, while the nerve runs forwards through the fibres of the muscle.

The Collateral Branches of the Hypoglossal Nerve.

Some of these are *anastomotic*. Thus, as it crosses the three divisions of the eighth nerve, the hypo-glossal lies in contact with the pneumogastric nerve, with which it sometimes communicates by very delicate filaments. Most commonly the anastomosis between these two nerves forms a true plexus. † This communication is sometimes effected with the anastomotic branch of the spinal accessory, sometimes with the pneumogastric itself.

The hypo-glossal is also connected by a very small anastomotic twig to the superior cervical ganglion.

It also receives three filaments from the nervous loop formed by the union of the first and secoud cervical nerves, namely, two from the first nerve and one from the second. The superior filament from the first nerve ascends, an arrangement which it is difficult to understand, for it passes in a direction towards the roots of the hypo-glossal; if it be supposed that this filament is derived from the hypo-glossal, then it is directed towards the roots of the first cervical nerve.

Opposite to the anterior border of the hyo-glossus it gives off a very remarkable anastomotic branch which forms an arch with the lingual nerve.

The other collateral branches which it gives off are the *descending branch*; a *small muscular infra-hyoid branch*; and the *branches for the hyo-glossus* and *stylo-glossus*.

* The vertebral artery is situated in front of the filaments of the hypo-glossal.

† [In connexion with this fact, it may be observed that the descendens noni (a branch of the hypo-glossal nerve) sometimes arises in part or entirely from the pneumogastric lower down in the neck.]

The descending branch (*ramus descendens noni, h, figs.* 298. 300, 301.). This is the most remarkable branch of the hypo-glossal nerve.* It comes off at the point where the nerve changes its direction, descends vertically in front of the internal carotid and then of the common carotid, curves outwards, and anastomoses upon the internal jugular vein with the descending branch of the cervical plexus (*z, fig.* 298.) so as to form a loop, having its concavity turned upwards. From the convexity of this loop two branches proceed, of which one is distributed to the omo-hyoid, whilst the other (*g*) divides into two twigs, one of which enters the outer border of the sterno-hyoid, while the other penetrates the deep surface of the sterno-thyroid muscle. I have seen one of these branches come directly from the hypo-glossal.†

It is equally important to study both the mode of origin and anastomosis of the descending branch of the ninth nerve.‡ The *origin* of this branch is, in fact, almost entirely from the anastomotic branches of the first and second cervical nerves, which, after having been in contact with the hypo-glossal, are given off from it to constitute the descending branch. This arrangement is especially evident in preparations that have been macerated in diluted nitric acid. I should state, however, that it is not equally evident in all subjects; and that some filaments, derived from the hypo-glossal itself, always join those from the cervical nerves. It has appeared to me that the most internal of the filaments derived from the hypo-glossal nerve itself followed a retrogade course; that is to say, that it ran from below upwards, as if it arose at the terminal extremity of the hypo-glossal, and then left that nerve to join the descendens noni at the point where that branch is given off.

The branches from the first and second cervical nerves to the hypo-glossal should be regarded as late origins of that nerve, which is sensibly increased in size after being joined by them. I have seen the third and even the fourth cervical nerve assist in the formation of the descendens noni; the branch from the fourth nerve arose partly from the phrenic.

The *mode of anastomosis* of the descendens noni with the descending branch of the cervical plexus, or rather of the third cranial nerve, is subject to much variety.

The following is the most frequent arrangement:

All the filaments composing these two descending branches unite together,

* See note, last page.

† [Another branch is described and figured by Arnold as descending in front of the vessels, and joining the *cardiac* nerves in the thorax.]

‡ There are certain cases in which the descendens noni is analysed by nature; namely, when the branch from the second cervical nerve is not applied to the hypo-glossal, but remains at a distance from it. In this case the filaments derived from the hypo-glossal join themselves to this branch; one of them ascends towards the origin of the second cervical nerve, and the others proceed towards its termination. In one case, the hypo-glossal gave a very small twig to the first cervical nerve, before receiving its accustomed branch from that nerve; the descending branch from the cervical plexus was replaced by three branches derived from the first, second, third, and fourth cervical nerves, which formed together with the descendens noni and its branches, a succession of loops, in front of the external and common carotids. In another case, the three superior cervical nerves assisted in forming the descendens noni. The following is a detailed description of that case, which throws considerable light upon the connexions between the hypo-glossal and cervical nerves. One large branch proceeded from the anastomotic arch of the first and second cervical nerves; this large branch, as soon as it reached the hypo-glossal nerve, divided into three filaments of unequal size; an ascending, which was directed towards the origin of the hypo-glossal nerve; a middle, which became blended with that nerve; and a descending, which was the largest, and which merely ran along in contact with the same nerve. At the point where this last-named filament left the hypo-glossal to form the descendens noni, it evidently received a twig from the hypo-glossal itself, which came from the lower part of that nerve, and was reflected upon the descendens noni in a retrograde manner, so that this twig, derived from the hypo-glossal, had one end at the terminal extremity of that nerve, *i. e.* in the muscles of the tongue, and the other end in the muscles of the infra-hyoid region. In this same case, the descending branch of the second cervical nerve divided into three filaments, one of which joined the hypo-glossal nerve, another formed an anastomotic arch with the third cervical nerve, whilst the third filament passed downwards to assist in forming the descending branch of the cervical plexus. Lastly, the third cervical nerve in this case gave off an ascending branch which anastomosed with the second, and a descending branch which assisted in forming the descending branch of the cervical plexus; there were therefore two loops or arches, one internal and the other external; they were situated opposite to the bifurcation of the common carotid artery.

with the exception of the uppermost filament, which describes a loop having its concavity turned upwards and resembling a vascular anastomosis; so that if we suppose it to be derived from the loop of the hypo-glossal, it would be directed towards the origin of the cervical nerves, and if, on the contrary, we suppose it to arise from the cervical nerves, it would be directed towards the origin of the hypo-glossal. This arrangement, which I have had the opportunity of observing in many parts of the nervous system, appears to me to constitute a mode of anastomosis well worthy the attention of physiologists. I am induced to regard it as intended to establish connexions between the different points of the spinal cord.*

The small muscular branch of the infra-hyoid region. This nerve comes off at the posterior border of the hyo-glossus, and ramifies in the upper part of the muscles of the infra-hyoid region; a small transverse filament runs along the hyoid attachments of these muscles. This small nerve may be regarded as an accessory to the descendens noni.

The branches for the hyo-glossus and stylo-glossus. As the hypo-glossal nerve comes into contact with the hyo-glossus, it becomes flattened and widened, and gives off several ascending branches, most of which ramify in the hyo-glossus, though several end in the stylo-glossus.

The Terminal Branches of the Hypo-glossal Nerve.

Opposite to the anterior border of the hyo-glossus the hypo-glossal nerve gives off some twigs to the under surface of the genio-hyoideus; it then enters the genio-hyo-glossus and expands (*d* near *x*, *fig.* 300.) into a great number of filaments which run forwards, perforate that muscle at successive points, and are lost in the substance of the tongue. It is impossible to follow these filaments to the papillary membrane of the tongue. Some of them anastomose with the lingual (*n*) nerve, a branch of the inferior maxillary division of the fifth; several accompany the lingual artery.

The relations of the lingual portions of the hypo-glossal nerve with the lingual of the fifth are worthy of attention. The lingual nerve occupies the under part of the border of the tongue, runs along the styloglossus, and may be traced as far as the apex of the organ: it is submucous in the whole of its extent. The hypo-glossal nerve is situated on a much lower plane, and occupies the under surface of the tongue, on each side of the median line.

Function. The hypo-glossal is a muscular nerve: it regulates the movements of the tongue, whilst the lingual of the fifth and the glosso-pharyngeal confer sensibility upon it. This fact is most clearly established by anatomical, physiological, and pathological observations. Like all nerves having a simple distribution, the hypo-glossal has not a plexiform structure.

General View of the Cranial Nerves.

All the spinal nerves present the greatest regularity in arising from two series of roots, in having a ganglionic enlargement on their posterior roots, and even in their course and termination, the differences or modifications of which depend on the different structure of the parts to which they are distributed; but the greatest irregularity appears to prevail in reference to the origin, the course, and the termination of the cranial nerves. From the comparison which has been made between the skull and the vertebræ, and from the possibility of resolving the bones of the cranium into a certain number of cranial vertebræ, anatomists have entertained the idea of drawing a parallel

* This mode of anastomosis may perhaps have some relation to that *reflex action of the spinal cord*, which Dr. Marshall Hall believes to be the cause of certain instinctive motions. ("On the Reflex Functions of the Medulla Oblongata and Medulla Spinalis." *Phil. Trans.* 1833.)

between the cranial and the spinal nerves. It has been conceived that the number of cranial nerves ought to be regulated by the number of cranial vertebræ admitted by different anatomists; and moreover, that in order to draw a fair comparison between these two sets of nerves, the special nerves of the face, namely, the olfactory, the optic, and the auditory nerves should be entirely disregarded.

Now we have already shown (see OSTEOLOGY), that there are three cranial vertebræ, between which there are two intervertebral foramina; that the anterior intervertebral foramen is represented by the sphenoidal fissure, to which we must annex the foramen rotundum and the foramen ovale; and that the posterior intervertebral foramen is represented by the foramen lacerum posterius together with the anterior condyloid foramen.

This being premised, we shall admit two pairs of cranial nerves, an anterior and a posterior.

The *posterior cranial pair* consists on each side of the eighth and ninth nerves, namely of the pneumogastric, glosso-pharyngeal, spinal accessory, and hypo-glossal nerves. The pneumogastric and the glosso-pharyngeal, each of which has a ganglion analogous to the intervertebral ganglia, represent the posterior roots of a spinal nerve, whilst the spinal accessory and the hypoglossal, which have no ganglion, represent the anterior root. The two last-named nerves are exclusively motor, whilst the pneumogastric and the glosso-pharyngeal appear to me to be mixed nerves, that is both sensory and motor.

The *anterior cranial pair* is composed on each side of the fifth nerve, the ganglion of which is quite analogous to the intervertebral ganglia, and the large portion of the root of which accurately represents the posterior root of a spinal nerve; and of the third or common motor nerve of the eye, of the fourth or pathetic nerve, of the sixth or external motor nerve of the eye, of the portio dura of the seventh, and lastly, of the non-ganglionic portion of the fifth. All these last-named nerves are the nerves of motion; whilst the ganglionic portion of the fifth is the nerve of sensation.

Moreover, as the spinal nerves communicate with the ganglia of the great sympathetic, it is of importance, for the completion of our comparison, to determine the communications of the two cranial pairs of nerves with the same system of ganglia. Now, I regard the *superior cervical ganglion* of the great sympathetic as common to the two supposed cranial pairs and to the three superior cervical pairs; in fact, the superior cervical ganglion communicates with all the branches of the posterior cranial pair, excepting the spinal accessory, viz. with the pneumogastric, the glosso-pharyngeal, and the hypo-glossal; and it also communicates with the anterior cranial pair, and more particularly with the fifth and sixth nerves.

As to the ophthalmic, spheno-palatine, otic, and submaxillary ganglia, which Arnold regards as annexed to the organs of the senses, viz. the ophthalmic to the eye, the spheno-palatine to the nose, the otic to the ear, and the submaxillary to the organ of taste, and which Bichat described as the cephalic portion of the great sympathetic, I am of opinion that they are mere local ganglia which do not form part of the general sympathetic system: besides, the ophthalmic and the otic ganglion only can be shown to be connected with the organs of any sense; it is impossible to show that the spheno-palatine ganglion, the very existence of which as a ganglion is often doubtful, has any connexions with the organ of smell, nor that the submaxillary ganglion, which is much more closely connected with the sublingual gland, has any relations with the organ of taste.

THE SYMPATHETIC SYSTEM OF NERVES.

General Remarks. — The Cervical portion of the Sympathetic. — The superior cervical ganglion — its superior branch, carotid plexus, and cavernous plexus — its anterior, external, inferior, and internal branches. — The middle cervical ganglion. — The inferior cervical ganglion. — The vertebral plexus. — The Cardiac nerves; right, superior, middle and inferior; left. — The Cardiac ganglion and plexuses. — The Thoracic portion of the Sympathetic. — The external and internal branches. — The splanchnic nerves, great and small. — The visceral ganglia and plexuses in the abdomen, viz. the solar plexus and semilunar ganglia. — The diaphragmatic and supra-renal, the cœliac, the superior mesenteric, the inferior mesenteric, and the renal, spermatic, and ovarian plexuses. — The Lumbar portion of the Sympathetic. — The communicating, external, and internal branches. — The lumbar splanchnic nerves and visceral plexuses in the pelvis. — The Sacral portion of the Sympathetic. — General view of the Sympathetic System.

We have seen that the nerves arising from the cerebro-spinal axis are distributed to the organs of the senses, to the skin, to the muscles, in short to all the organs of animal life. The pneumogastric nerve alone is distributed to the organs of respiration, and the upper part of the alimentary canal, viz. the pharynx, the œsophagus, and the stomach. We shall now see that all the internal organs, which are beyond the influence of volition and consciousness, are provided with a special nervous apparatus which is called the *great sympathetic*, the *sympathetic system*, the *ganglionic system*, or the *nervous system of organic or nutritive life.*

The *sympathetic system* consists of two long, knotted cords (*f* to *v*, *fig.* 268., in which figure these cords are represented as if drawn outwards away from their natural position) extended one on each side of the vertebral column, from the first cervical to the last sacral vertebra; these cords are enlarged opposite each vertebra to form a series of ganglia, which communicate with all the spinal and cranial nerves on the one hand, and give off all the visceral branches on the other. The sympathetic system consists essentially of two distinct parts: of a *central portion*, formed by the two cords; and of a *visceral, median,* or *prævertebral portion*, consisting of certain plexuses and ganglia which communicate with the central cords, surround the arteries as if in sheaths, penetrate the viscera with them, and establish a communication between the sympathetic cords of the right and left sides. We cannot pay too much attention to the connexion between the ganglionic nerves and the arteries, which always serve as a support for these nerves, and for which, according to some anatomists, the nerves are exclusively destined.

Each half of the sympathetic system may be described in two ways, either as a continuous cord, having ganglia at intervals upon it, or as a series of ganglia or centres, which may first be examined independently of each other, and around which all the filaments that enter or emerge from them may then be arranged.

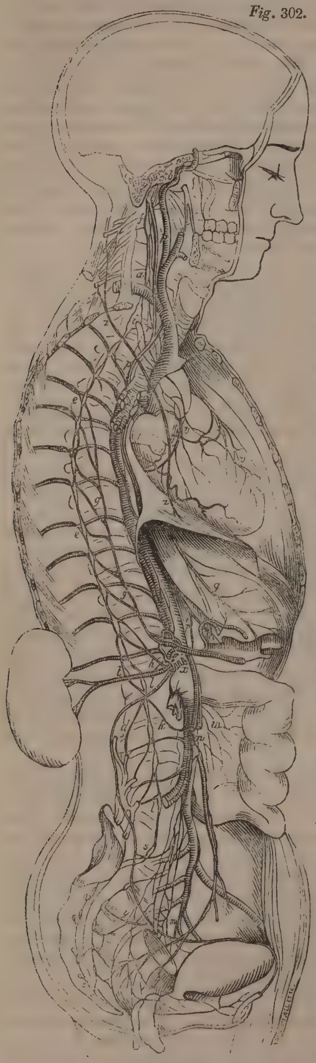
The first method, which is the more natural one, was adopted by the older anatomists, who described the sympathetic in the same way as other nerves; according to the second method, which is the one adopted by Bichat, all the ganglia, whatever situation they may occupy, are included in the sympathetic system; the ophthalmic, the spheno-palatine, and other cranial ganglia would, according to this view, be comprised in the sympathetic system.

I believe that the better mode of description is one which associates the idea of a centre with that of a cord. In fact, as the sympathetic system consists of a double line, it is natural to describe it as a nervous cord, having two extremities, one cephalic, the other pelvic; and as each ganglion forms the point of termination or of origin to a great number of nervous filaments, these bodies may very properly be regarded as central points. The visceral portion of the

sympathetic nerves will be described with the ganglia to which they are connected.

I shall describe in succession the cervical, the thoracic, the abdominal, and the pelvic portion of the sympathetic. I have already said that I do not recognise any proper cephalic portion of this system of nerves, for the ophthalmic and the other cranial ganglia seem to me to belong to a totally different class.

Fig. 302.



The Cervical Portion of the Sympathetic System.

The *cervical portion of the sympathetic* (*f i*, *fig.* 302.) has this peculiarity that, instead of being composed of as many ganglia as there are vertebræ, it has only two or three. This may be explained by supposing that the superior cervical ganglion represents by itself the ganglia which are wanting. It will hereafter be seen that the lumbar ganglia are rather frequently fused in a similar manner. The cervical portion of the sympathetic is situated on the anterior region of the vertebral column, behind the internal and common carotid arteries, the internal jugular vein and the pneumogastric nerve (*p*). It is connected to all these parts, and to the prævertebral muscles, by some very loose cellular tissue; a layer of fascia intervening between them; it commences by a large fusiform ganglion, the *superior cervical ganglion* (*f*); this is succeeded by a nervous cord of variable size, which terminates in the *middle cervical ganglion* (*a*) when that exists, but when it is absent in the *inferior cervical ganglion* (*i*), which is continuous with the first thoracic ganglion, either directly, or through the medium of two or three very remarkable nervous loops, or frequently by both methods of connexion. We shall proceed to examine the three cervical ganglia.

The Superior Cervical Ganglion.

Dissection. Remove the corresponding ramus of the lower jaw, separate the ganglion very carefully from the pneumogastric, glosso-pharyngeal, and hypo-glossal nerves, behind which it is placed. In order to trace the superior or carotid branch, make an antero-posterior median section of the head, open behind in the manner indicated for exposing the pneumogastric, and then examine the ganglion and its superior branch from the inner side.

The *superior cervical ganglion* (*f*) is olive-shaped or fusiform: it is situated in front of the second and third cervical vertebræ, from which it is separated by the rectus capitis anticus; it is behind the internal carotid artery, and the glosso-pharyngeal, pneumogastric, and hypo-glossal nerves; its upper extremity is about ten or twelve lines distant from the lower orifice of the carotid canal; it is said to have been found two inches from it.

It is larger than the other cervical ganglia (*ganglion cervicale magnum*), but it varies much both in its length and its other dimensions; thus, its lower extremity has been seen to reach the fourth, fifth, and even the sixth cervical vertebra. Its colour is greyish, and its surface smooth: not unfrequently it is bifurcated at its lower extremity; it is rather often double. Lobstein has figured a case of this kind; and there were also two superior cervical ganglia, one placed above the other, in a case of hypertrophy of these ganglia, examined and represented by myself. (*Anat. Path.* liv. i. pl. 3.)

These cases of a double superior cervical ganglion evidently depend on subdivision of the single ganglion usually existing.

The branches which end in or emerge from the superior cervical ganglion may be divided into *superior*, *inferior*, *external*, *internal*, and *anterior*. I shall divide them into those which communicate with the cranial and cervical nerves, those which communicate with the other cervical ganglia, and into arterial and visceral branches. The superior cervical ganglion also gives off several twigs to the muscles of the prævertebral region.

The superior cervical ganglion communicates with the cranial nerves by means of its superior or carotid branch and its anterior branches. It communicates with the cervical nerves by its external branches. It communicates with the other cervical ganglia by its inferior branch. Its visceral and arterial branches are the pharyngeal, the cardiac, and the branches for the external carotid.

The Superior or Carotid Branch from the Inferior Cervical Ganglion.

The *superior* or *carotid branch*, or the branch of communication with the nerves which constitute the anterior cranial pair, has been for a long time regarded as the origin of the sympathetic nerve; and as, previously to the time of Meckel, the anastomosis of this carotid branch with the sixth cranial nerve, or external motor of the eye, was the only one known, it was supposed that the sympathetic arose from the sixth nerve; the discovery of the vidian nerve by the elder Meckel has led to the admission of two origins or roots of the sympathetic, namely, one from the fifth and another from the sixth cranial nerve.

Since the researches of modern anatomists, the study of the superior or carotid branch of the superior cervical ganglion, has become one of the most complicated points in the anatomy of the nervous system.

This carotid branch appears to be a prolongation of the superior cervical ganglion; it tapers as it approaches the carotid canal, into which it enters, after having divided into two branches, one of which runs on the inner side and the other on the outer side of the artery. These branches communicate with each other, subdivide, and unite to form the *carotid plexus*, and having reached the cavernous sinus form a plexus, named the *cavernous plexus*, which gives off the communicating branches to the sixth and fifth nerves, and also the small plexuses which surround the internal carotid and its branches.*

Laumonier, and after him Lobstein and several others, described a ganglion, named the *carotid ganglion*, in the first turn of the carotid canal; but it is in vain to search for it, unless some slight enlargements on the external and internal branches, wherever they give off or receive twigs, are to be regarded as ganglionic.†

* The carotid branch is sometimes single, and turns spirally around the artery, being placed at first behind, then on the outer side, next on the inner, and again on the outer side of the vessel.

† Arnold, whose authority upon such a subject is of great weight, has never seen this ganglion;

During their course in the carotid canal, the external and internal divisions of the carotid portion of the sympathetic give off the following branches : —

An anastomotic twig to the nerve of Jacobson. This comes off from the external branch, and is very small; it perforates the external wall of the carotid canal, enters the cavity of the tympanum, and anastomoses with the nerve of Jacobson, a branch of the glosso-pharyngeal.

An anastomotic twig to the spheno-palatine, or Meckel's ganglion. This, like the preceding, comes from the external division of the carotid branch of the sympathetic, and passes to the vidian or pterygoid branch of the superior maxillary nerve. We have already spoken of this twig, under the name of the carotid or deep branch of the vidian nerve. Anatomists differ as to whether it should be regarded as passing from the fifth nerve to the superior cervical ganglion, or from the superior cervical ganglion to the fifth nerve. Arnold, on account of its greyish colour, and slight consistence, regards it as coming from the superior cervical ganglion, whilst he believes the great superficial petrosal nerve, *i. e.* the cranial branch of the vidian, also from its colour and consistence, to belong to the cerebro-spinal system of nerves, and to be a branch of the fifth nerve. I have already said that I have never found sufficient difference between the superior petrosal and carotid branches of the vidian to warrant this distinction. These two nerves are moreover perfectly distinct from each other as far as the spheno-palatine ganglion, in which they terminate.

It is important to observe that the two branches of the vidian nerve terminate in the enlargement called the spheno-palatine, or Meckel's ganglion: the connexion of this ganglion with the superior cervical ganglion has not been overlooked by those anatomists who regard the spheno-palatine enlargement as a ganglion, and who consider the cranial ganglia as forming part of the sympathetic system.

Anastomotic branches to the sixth nerve. Several branches, generally three, turn round the convex side of the second curve of the internal carotid, reach the outer side of that artery, and anastomose, either separately, or after having united together, with the sixth or external motor oculi nerve. The nerves join at an acute angle opening backwards, within the cavernous sinus, and at the point where the sixth nerve crosses the carotid: as this nerve becomes flattened and widened opposite to the artery, it has been imagined that it was really enlarged, and that this augmentation was due to the addition of filaments from the sympathetic nerve; but the enlargement is only apparent, and notwithstanding the difference in colour, I should be inclined to admit that the communicating filaments between the sixth nerve and the carotid branches of the sympathetic are furnished by the sixth nerve and have a reflected course. I have seen the three communicating filaments between the upper part of the sympathetic and the sixth nerve form a gangliform enlargement as they were about to join the latter; and it was this gangliform enlargement which gave origin to the plexus surrounding the internal carotid artery and its branches.

The Cavernous Plexus.

The *cavernous plexus*, in which the two divisions of the carotid branch of the superior cervical ganglion at length terminate, is situated on the inner side of the carotid artery, at the point where that vessel enters the cavernous sinus. From this greyish plexus, which is intermixed with small vessels (plexus nervoso-arteriosus, *Walter*), a considerable number of filaments proceed, some of which establish a communication between it and the fifth nerve, whilst others surround the internal carotid, and accompany all its ramifications. The following very numerous branches emerge from the cavernous plexus:

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he very properly remarks that, even those anatomists who admit the existence of it are not agreed as to its situation.

Some communicating filaments to the third nerve or external motor oculi before the division of that nerve. These filaments pass above the sixth nerve, to which they appear to be applied.*

A filament of communication with the ophthalmic ganglion. This arises from the anterior part of the cavernous plexus, enters the orbit between the third nerve and the ophthalmic division of the fifth, and unites sometimes with the long root of the ophthalmic ganglion, which we have stated to be derived from the nasal branch of the ophthalmic, and sometimes with the ophthalmic ganglion itself.

This root had been described and figured by Lecat, before Bock, Ribes, and Arnold recalled the attention of anatomists to it.

It follows from the arrangement just described, that the ophthalmic ganglion has three roots, two cerebro-spinal and one ganglionic.

Communicating filaments to the fifth nerve: some of these pass to the Gasserian ganglion, and others to the ophthalmic division of the fifth.†

The filaments which accompany the internal carotid artery and its branches: these are extremely delicate, but they are beautifully distinct in some subjects. They may be followed even upon the branches of the internal carotid.

Anatomists admit the existence of a plexus for the ophthalmic artery, and for each of its subdivisions. It is even supposed that there is one for the arteria centralis retinæ.‡

Several authors have described a certain number of filaments proceeding from the cavernous plexus to the pituitary body (filets sus-sphénoidaux, *Chaussier*). I have never been fortunate enough to discover them, nor yet the ganglion (the ganglion of Ribes) which is said to exist upon the anterior communicating artery of the brain, and which is found at the point of junction of the right and left trunks of the sympathetic.

It follows from what has been stated, that the superior cervical ganglion, by means of its upper or carotid branch, communicates with most of the nerves of the anterior cranial pair; namely, with the fifth nerve, by means of the Gasserian ganglion, of the ophthalmic division of the fifth, and of the ophthalmic ganglion, either directly or indirectly; also by means of the superior maxillary division of this nerve, through the intervention of the spheno-palatine ganglion; secondly, with the third nerve; and lastly with the sixth.

The Anterior Branches from the Superior Cervical Ganglion.

The *anterior branches* of the superior cervical ganglion establish a *communication* with the different nerves of the *posterior cranial pair*, excepting the spinal accessory nerve, which does not appear to have any direct communication with it.

The glosso-pharyngeal and pneumogastric nerves communicate with the superior cervical ganglion at two different points, viz. at their ganglia, and by their branches.

The communication of the superior cervical ganglion with the *ganglia* of the glosso-pharyngeal and pneumogastric nerves has been pointed out by Arnold; it is difficult to demonstrate it through the dense tissue which surrounds these ganglia.

On the contrary, it is extremely easy to demonstrate the communications of the glosso-pharyngeal nerve and the plexiform cord of the pneumogastric with the superior cervical ganglion. I have already said (see PNEUMOGASTRIC NERVE) that in one case I found the pneumogastric so closely applied to the whole length of the superior cervical ganglion, that it was im-

* I have never seen the communication between the superior cervical ganglion and the facial nerve noticed by some anatomists.

† I may here again notice that in two subjects I have seen a twig from the spheno-palatine ganglion join the communicating branches between the sixth nerve and the sympathetic.

‡ M. Ribes, Mémoires de la Société Médicale d'Emulation, t. vii.

possible to separate them. The communication of the superior cervical ganglion with the hypo-glossal is quite as evident as the preceding.

The filaments of communication with the nerves forming the posterior cranial pair do not always proceed from the superior cervical ganglion itself, but sometimes from its carotid branch.

The External Branch from the Superior Cervical Ganglion.

The *external branches* of the superior cervical ganglion establish a *communication* between it and the *first, second, and third cervical nerves;* they are large, have a grey colour, and a ganglionic structure; we may regard them as true prolongations of the superior cervical ganglion; the principal of them enter the angle of bifurcation of the second cervical nerve, into its ascending and descending branches; the others, which are very small, join the first cervical nerve. They constitute a true ganglionic plexus, and often form two distinct groups.

Frequently the superior cervical ganglion communicates only with the first and second cervical nerves. At other times it also communicates with the third and fourth nerves by means of a long and very oblique branch. In one case it communicated directly with the phrenic nerve.

The Inferior Branch from the Superior Cervical Ganglion.

The inferior branch from the superior cervical ganglion, or the branch of communication with the middle cervical ganglion, is a white cord, resembling a spinal nerve, excepting in a few cases in which it appears to be a prolongation of the tissue of the ganglion itself: when the lower extremity of the superior cervical ganglion is divided into two parts, its inferior branch arises from the external division. It varies much in size in different subjects: it descends vertically in front of the spinal column, behind the common carotid, the internal jugular vein, and the pneumogastric nerve, to which it is united by a very loose cellular tissue.

Having reached the inferior thyroid artery, the cord of the sympathetic passes behind that vessel, and enters the middle cervical ganglion when that exists; but when it is absent, the cord continues on to join the inferior cervical ganglion. As it descends, it most commonly receives some twigs from the third and fourth cervical nerves, which twigs we have already said occasionally enter the superior cervical ganglion. At its origin, it gives off on the inner side two filaments which join the superior cardiac nerve and increase its size; and an anastomotic twig to the external laryngeal nerve, a branch of the superior laryngeal. Not unfrequently the superior cardiac nerve arises entirely from the communicating branch between the superior and middle cervical ganglia, that branch appearing to bifurcate.

The communication between the superior and middle cervical ganglia is subject to much variety. I have seen a small ganglion upon it opposite to the inferior thyroid artery; from this ganglion, which rested upon the artery, and which might be regarded as the vestige of a middle cervical ganglion, two cords proceeded, an anterior which joined the cardiac nerve, and a posterior, which ended in the inferior cervical ganglion: both of these had a gangliform structure. The cord of the sympathetic is not uncommonly found enlarged at intervals into ganglionic nodules.

The Internal Branches, or Carotid and Visceral Branches.

The *internal branches from the superior cervical ganglion* are divided into those which accompany the external carotid and its ramifications, and those which are distributed to the viscera.

The carotid branches. It has been stated that from the upper extremity of the superior cervical ganglion certain branches are given off, which surround the internal carotid, and are prolonged upon its ramifications.

From the inner border of the same ganglion other branches proceed, which embrace the external carotid and the ramifications of that vessel.

These nerves are of a grey colour (*subrufi*), of a soft texture (nervi molles et pene mucosi, *Scarpa*), and of a knotted and gangliform structure (rami gangliformes, *Neubauer*); they come off from the ganglion opposite to the origin of the facial artery; they pass inwards behind the external and internal carotids, and form a sort of grey plexus which extends as far as the origin of the internal and external carotid *; they turn like a loop around the former of these vessels and anastomose with the carotid filaments from the glosso-pharyngeal, and from the pharyngeal and superior laryngeal branches of the pneumogastric. None of the branches from this plexus are prolonged upon the common carotid; they all pass upon the external carotid and its different ramifications, forming as many plexuses as there are vessels, and are distributed with those vessels to the neck and the face. Thus, there is a *thyroid plexus* which surrounds the superior thyroid artery, and may be traced into the thyroid body; a *lingual plexus* which enters the substance of the tongue, and is supposed to anastomose with the lingual branch of the inferior maxillary division of the fifth, and even with the hypo-glossal nerve; and a *facial plexus* which is supposed to anastomose with the facial nerve. Anatomists have particularly directed their attention to the branches which enter the sub-maxillary gland; some imagining, and others regarding it as certain, that these branches communicate with the submaxillary ganglion. I have never been fortunate enough to discover this communication.

There is moreover a *pharyngeal plexus*, an *occipital plexus*, and an *auricular plexus*: the elder Meckel † has even described an anastomosis between the facial nerve and the sympathetic filament which accompanies the posterior auricular artery. Lastly, the temporal artery, and the internal maxillary artery and its divisions, are also surrounded (hederæ ad modum, *Scarpa*) by small nervous plexuses; these plexuses are sometimes so well developed, that the elder Meckel states that the arteries of the face have larger nervous plexuses than any others in the body. These plexuses appear to me to be peculiarly remarkable for containing a mixture of white fibres and nervi molles, which proves their double origin.

All these plexuses present gangliform enlargements at various points, as is shewn in the splendid plate in Scarpa's work. ‡ This author has figured after Andersh a ganglion which he believes to be constant at the division of the external carotid and temporal arteries. A twig from the facial nerve terminates in this ganglion.§

The visceral branches. All these come off from the inner side of the ganglion, and divide into pharyngeal, laryngeal, and cardiac branches.

The *pharyngeal branches* are certain thick ganglionic cords which arise from the upper and inner part of the superior cervical ganglion, pass transversely inwards, and combine with the pharyngeal branches of the glosso-pharyngeal and pneumogastric nerves to form one of the most remarkable plexuses in the body, which is distributed to the pharynx. To this plexus must be referred all those highly important nervous phenomena which are manifested in connexion with the pharynx, more particularly the sensation of thirst.

The *laryngeal branches* unite with the superior laryngeal nerve and its divi-

* At this division there is frequently a gangliform enlargement, which Arnold proposes to call the *inter-carotid ganglion*.

† Mémoires de l' Acad. de Berlin, 1752.

‡ Tabulæ Neurologicæ, tab. iii. 1794.

§ Arnold has described and figured a twig from the plexus which surrounds the middle meningeal or spheno-spinous artery, and which, according to this laborious inquirer, terminates in the otic ganglion; he also describes some nervous twigs, passing from the plexus of the ascending palatine artery to the submaxillary ganglion. In this way he establishes a connexion between the sympathetic system and these two cranial ganglia. I have devoted great care to this subject, but have never been able to make out these communicating filaments, even though all the difficult dissections have been made upon specimens previously macerated in diluted nitric acid.

sions. In a case in which the external laryngeal nerve arose separately from the pneumogastric and not from the superior laryngeal, it had as many filaments of origin from the superior cervical ganglion as from the pneumogastric itself.

The *cardiac branches* form the superior cardiac nerve, to which I shall recur after having described the middle and inferior cervical ganglia.

The Middle Cervical Ganglion.

The *middle cervical ganglion* (*a. fig.* 302.) is wanting in a great number of subjects, and then the branches usually given off from and received by it are given off and received by the cords which connect the superior and inferior cervical ganglia, or by the inferior cervical ganglion itself. The middle cervical ganglion is sometimes double; at other times it is in quite a rudimentary state.

It is situated on a level with the fifth or sixth cervical vertebra, in front of the inferior thyroid artery, opposite to the first curve of that vessel, and sometimes behind it; its relation to this artery, which is very nearly constant, induced Haller to name it the *thyroid ganglion:* however, I have frequently seen it eight lines above that artery. Its form and size are extremely variable, not only in different subjects, but even upon opposite sides of the same subject. Sometimes it is a simple gangliform enlargement. Scarpa has figured a middle cervical ganglion almost as large as the superior, and like it olive-shaped. I have never seen it as large as this.*

The middle cervical ganglion, when it exists, receives:

Above, the cord which communicates with the superior cervical ganglion; *below*, the cord of communication, often multiple, with the inferior cervical ganglion; *on the outside*, three branches derived from the third, fourth, and fifth cervical nerves: not unfrequently the communicating branch from the fourth cervical nerve belongs to the phrenic; on the *inside*, the *middle cardiac nerve*, or *great cardiac of Scarpa*, which I shall presently describe.

The size of the middle cervical ganglion has always appeared to me to be proportioned to that of its filaments of communication with the cervical nerves.

The Inferior Cervical Ganglion.

Neubauer has given an excellent description of the inferior cervical ganglion under the name of the first *thoracic ganglion*, rather an appropriate title for it, because it is frequently continuous with the first thoracic ganglion (as at *i*, *fig.* 302.); and secondly, because it is situated in front of the transverse process of the seventh cervical vertebra and of the head of the first rib. This ganglion is constant; it is deeply seated behind the origin of the vertebral artery, by which it is completely concealed.†

It is of a semilunar shape, its concave border being turned upwards and its convex one downwards; at its internal extremity it receives the trunk of the sympathetic; at its external extremity it receives a large nerve which accompanies the vertebral artery, and which may be called the *vertebral nerve;* at the same extremity it also receives some communicating branches from the fifth, sixth, and seventh cervical nerves, and often from the first dorsal. Several branches proceed from its convex border which is turned downwards; some pass in front of and others behind the subclavian artery, which they embrace like loops. Most of these inferior branches are the communicating branches between the inferior cervical and the superior thoracic ganglion, and

* I believe that it is incorrect to regard as a middle cervical ganglion those ganglionic nodules, without either afferent or efferent filaments, which are rather frequently found at various points on the trunk of the sympathetic.

† It is not rare to see the inferior cervical ganglion describe around the vertebral artery a half-ring which is completed in front by a grey cord extended from one end of the ganglion to the other.

they exist even when the two ganglia are directly continuous with each other. One of the branches sometimes joins the recurrent laryngeal branch of the pneumo-gastric; the most remarkable of the inferior branches constitutes the *inferior cardiac nerve*, which is rather frequently derived from the superior thoracic ganglion.

To complete the description of the cervical portion of the sympathetic, we have now only to speak of the *vertebral nerve* and of the *cardiac nerves.*

The Vertebral Plexus.

The *vertebral plexus* or *vertebral nerve* occupies the canal which is formed for the vertebral artery in the transverse processes. It is generally said that this nerve arises from the inferior cervical ganglion; that it traverses the entire length of the canal formed for the vertebral artery, enters the cranium with that vessel, and then unites with its fellow of the opposite side to form the basilar plexus, which divides and subdivides around the terminal ramifications of the basilar artery, like the plexuses which are formed around the internal carotid; but such is not a correct description of the nerve. It appears to me to be formed by the junction of filaments derived from the third, fourth, and fifth cervical nerves, gradually to increase in size from above downwards as it receives new filaments, then to pass behind the artery, to emerge from the canal also behind the vessel, and finally to enter the inferior cervical ganglion. I conceive that this branch is intended to establish a communication between the third, fourth, and fifth cervical nerves and the inferior cervical ganglion. I have never found upon these branches the swellings or ganglia which, according to M. Blainville's ingenious idea, might be intended to supply the place of the cervical sympathetic ganglia, and to destroy the appearance of irregularity which exists in the cervical region in this respect.

The Cardiac Nerves.

Dissection. This comprises the dissection of the cardiac nerves, from their origin to the point where the aorta and pulmonary artery cross each other; and from that point to the extreme divisions of the nerves. For this purpose, after having previously exposed the cervical ganglia and the cardiac nerves, the preparation should be macerated in diluted nitric acid; all the internal nerves which proceed from the ganglion should then be carefully dissected, so as to preserve their relations with the cardiac branches of the pneumogastric and recurrent nerves; we must then examine the nerves which pass in front of the aorta, those which run between that vessel and the pulmonary artery and trachea and lastly, those which pass behind the pulmonary artery; we should study at the same time their relations with the anterior and posterior cardiac plexuses.

The *cardiac nerves*, or *nerves of the heart*, which are distinguished into the *right* and the *left**, arise essentially from the cervical ganglia. These ganglionic nerves are then joined by several branches from the pneumo-gastric; they all converge upon the origin of the aorta and pulmonary artery to form the *cardiac plexuses*, which give off the *right* and *left coronary plexuses;* these latter plexuses surround the coronary arteries, and their branches are scattered

* The history of the nerves of the heart is singular. The ancient philosophers, with Aristotle, influenced by certain preconceived ideas, stated that the heart was the source of all the nerves in the body. Galen refuted this opinion, and admitted that the heart had but one very small nerve, which descended from the brain. Vesalius considered that this slender nerve came from the recurrent, and represented it in a figure. Fallopius first described the nerves of the heart, and says that he showed his audience "*insignem nervorum plexum à quo abundans copia nervosæ materiæ totam cordis basim complexatur, perque ipsam plures propagines parvorum nervorum dispergit.*" Behrends in 1792 defended a thesis, in which he endeavoured to demonstrate that the *heart has no nerves, cor nervis carere*. Such was the amount of knowledge on this subject, when, in 1794, Scarpa published his splendid work, and settled the state of science on this point. (*Tabulæ Neurologicæ ad Illustrandam Anatomiam Cardiacorum Nervorum, Noni Nervorum Cerebri, Glosso-pharyngæi et Pharyngæi ex Octavo Cerebri*).

over the surface of the heart, but do not enter its substance, until they have advanced a considerable distance beneath the serous membrane by which the heart is covered.

Such is the most general idea that can be given of the cardiac nerves and plexuses, which afford one example of the most remarkable of the median anastomoses. Scarpa first described and figured them correctly in his plates, which will always be models for anatomical drawings. No nerves present so many varieties, in number, size, and origin, as the cardiac nerves; and on this subject especially, the want of a work upon anatomical varieties is especially felt. For my part, I declare that I have never found the cardiac nerves in my dissections as they are represented in Scarpa's magnificent plates, which have served as the type for all descriptions. I have minutely described the cardiac nerves in eight different subjects; these eight descriptions present very great differences, at least until one arrives at the account of the cardiac plexuses; the ultimate distribution of the nerves of the heart appeared to be the same in all these subjects.

All the cardiac nerves are grey, but they are not all soft, as declared by Scarpa, who called them *nervi molles*. Sometimes the right, and sometimes the left cardiac nerves are the larger; the nerves of the two sides are inversely proportioned to each other in this respect, and there is evidently a mutual dependence between them. In one case, in which the middle and inferior cardiac nerves of the right side were wanting, and the superior cardiac nerve very small, their places were supplied by some large branches from the right recurrent nerve, and by the left cardiac nerves, which were largely developed.

Anatomists follow Scarpa, in describing three cardiac nerves on each side: a *superior*, named by him the *superficial* cardiac nerve, which is derived from the superior cervical ganglion; a *middle*, called by him the *great* or *deep cardiac nerve*, which arises from the middle cervical ganglion; and an *inferior*, or *small* cardiac nerve, proceeding from the inferior cervical ganglion. Although this is the usual arrangement, it is often impossible to distinguish three nerves, in consequence of the anatomical varieties which I have already mentioned. There is frequently no middle cardiac nerve properly so called; at other times there is no inferior cardiac nerve, or rather they are both in a rudimentary state; lastly, the superior cardiac nerve, if not entirely wanting, may be extremely small, and may join the middle cardiac nerve. Sometimes all the cardiac nerves of one side unite into a single trunk, or else into a plexus situated behind the subclavian artery, upon the side of the trachea; the recurrent nerve assists in forming this plexus, from which three, four, or more branches are given off to be distributed to the heart in the usual manner. One of the most important points in the history of the cardiac nerves is their sort of fusion with the pneumogastric, which is so intimate that the cardiac branches of the pneumogastric, and those which come from the ganglia, form a single system. There is a similar fusion between the superior, middle, and inferior cardiac nerves of each side, and between the nerves of the two sides.

The recurrent nerve, in particular, appears sometimes to be distributed equally to the larynx and the heart, so large and numerous are the cardiac branches given off from it; it will hereafter be seen that there is an equally intimate connexion between the pneumogastric nerve and the solar plexus.

I shall first describe in detail the right cardiac nerves, and shall then briefly point out the differences between them and the left cardiac nerves.

The Right Cardiac Nerves.

The *superior cardiac nerve.* Its origin is very variable. Most commonly, it arises from the internal division of the bifurcated lower extremity of the superior cervical ganglion, the cord of communication between the superior and the next cervical ganglion forming the external division. At other times, it arises from the communicating cord. In a great number of cases it has several origins, being formed by two or three very small filaments, which come

from the inner side of the superior cervical ganglion; by a branch, often a large one, from the cord of communication; and by two filaments from the pneumogastric nerve. In one of these latter cases the cardiac branch from the cord of communication presented a very distinct ganglion.

Whatever may be its origin, the superior cardiac nerve passes obliquely downwards and inwards, behind the common carotid, from which it is separated by a very thin layer of fascia, so that it is almost impossible to include it in applying a ligature to that artery; it runs along the trachea, very often receives a branch from the trunk of the sympathetic, and crosses in front of the inferior thyroid artery, or sometimes divides into two branches, one of which, the *anterior*, passes in front of the artery, whilst the *posterior* joins the recurrent nerve.* At the lower part of the neck the superior cardiac nerve runs along the recurrent laryngeal nerve, with which it may be confounded; it enters the thorax, passing behind and sometimes in front of the subclavian artery †, runs along the brachio-cephalic trunk, gains the back of the arch of the aorta, gives off a certain number of filaments which pass in front of that part of the vessel, then runs obliquely downwards and to the left between the arch of the aorta and the trachea, anastomoses very frequently with the middle and inferior cardiac nerves and with the branches of the recurrent, and divides into two sets of filaments; some of these pass between the aorta and the pulmonary artery, and others between the right pulmonary trunk and the trachea; they both anastomose with the left cardiac nerves and are arranged as we shall soon describe. In some rare cases, the right superior cardiac nerve goes directly to the cardiac plexus, without anastomosing with the middle and inferior cardiac nerves.

During its course along the neck, the right superior cardiac nerve receives the small superior cardiac branches of the pneumogastric, and gives off several filaments, some to the pharynx, others to the trachea and the thyroid body, whilst several assist in forming the plexus of the inferior thyroid artery; it often gives off three or four branches which anastomose with the recurrent nerve.

In the thorax, the superior cardiac nerve is joined by the cardiac branch given off by the pneumogastric in the lower part of the neck, and which is sometimes of very considerable size, and evidently reinforces the cardiac nerve; this branch of the pneumogastric sometimes terminates directly in the cardiac plexus.

The middle cardiac nerve. This nerve arises from the middle cervical ganglion, or, when that is absent, from the trunk of the sympathetic, at a variable distance from the inferior cervical ganglion. It is rather frequently the largest of the cardiac nerves, and has therefore been called by Scarpa the *great* cardiac nerve (*magnus, profundus*). At other times it is in a rudimentary state, and is replaced either by the superior or the inferior cardiac nerve, or by branches from the recurrent: it frequently divides into several twigs between which the subclavian passes; it almost always anastomoses with the superior and inferior cardiac nerves of the same side, runs along the recurrent nerve, for which it might be mistaken, and with which it is always connected, and then terminates in the cardiac plexus.

The inferior cardiac nerve. This is generally smaller (*cardiacus minor*) than the preceding nerve, though it is sometimes larger; it usually

* The trunk of the sympathetic having reached the inferior thyroid artery sometimes divides into two branches, one of which passes in front of that artery, to join the superior cardiac nerve, whilst the other passes behind it to the inferior cervical ganglion; not unfrequently the superior cardiac nerve presents a ganglionic enlargement, which occupies the whole or a part of the thickness of the nerve.

† The superior cardiac nerve often bifurcates so as to embrace the subclavian artery in a complete ring. At other times the superior cardiac nerve passes behind the subclavian artery, and the cardiac branch of the pneumogastric in front of it, so as to form beneath the subclavian an anastomotic loop which lies to the inner side of the one formed by the recurrent nerve. Most commonly the cardiac branch of the pneumogastric anastomoses with the superior cardiac nerve between the arch of the aorta and the trachea.

arises from the inferior cervical ganglion, but rather frequently from the first thoracic; it accompanies the middle cardiac nerve, anastomoses with that nerve, and like it descends vertically in front of the trachea and terminates in the cardiac plexus.

The connexion of the middle and inferior cardiac nerves with the recurrent nerve demands especial attention. Sometimes the recurrent sends off certain large branches which join the cardiac nerves, and form their principal origin. I have seen the middle and inferior cardiac nerves united together, crossing over the recurrent nerve at right angles, and adhering intimately to it without presenting that admixture of filaments which constitutes an anastomosis.*

The Left Cardiac Nerves.

The peculiarities of the left cardiac nerves may be stated in a few words†: in the neck, they are situated in front of the œsophagus, on account of the position of that canal. The connexions between the cardiac nerves and the recurrent on the left side appear to me more numerous than those on the right. In one case, the superior and inferior cardiac nerves gave off a series of four rather large filaments, which ran along the recurrent, left that nerve opposite to its point of reflection, and then terminated in the usual manner. I ascertained that in this case the two nerves were merely in contact, and did not anastomose.

In the thorax, the superior and middle cardiac nerves of the left side descend between the carotid and subclavian and then run upon the concavity of the arch of the aorta; the inferior cardiac nerve, which is the largest of all the cardiac nerves in a subject which I have now before me, passes to the left of the trunk of the pulmonary artery, turns round its back part, and embraces it in a loop, so as to enter that portion of the cardiac plexus which is situated between the aorta and the right division of the pulmonary artery. Lastly, on the left side, more commonly than on the right, the anterior pulmonary plexus sends off some filaments to this same part of the cardiac plexus.

The Cardiac Ganglion and Plexuses.

We have seen that the cardiac nerves of the same side anastomose with each other, on the sides or in front of the trachea. Besides this, the right cardiac nerves anastomose with the left, upon the concavity of the arch of the aorta; also in front of the trachea, above the right pulmonary artery; and lastly, in the anterior and posterior coronary plexuses.

Wrisberg was the first to describe a ganglion in the situation of the first named anastomosis, that is to say, upon the concavity of the arch of the aorta between that vessel and the pulmonary artery, to the right of the remains of the ductus arteriosus. This ganglion, which is by no means constant, is named the *cardiac ganglion*; it is joined [so as to form the superficial cardiac plexus] by the superior cardiac nerve of the right side, by the same nerve of the left side, and sometimes also by the right and left cardiac branches given off from the pneumogastric nerves in the lower part of the neck.

The second anastomosis, or that which takes place in front of the trachea, above the right pulmonary artery, and behind the arch of the aorta, has been known, since the time of Haller, as the *great cardiac plexus* (magnus, profundus plexus cardiacus, *Scarpa*). A ganglionic enlargement is not unfre-

* It is especially in these anastomoses between the cardiac and recurrent nerves, that I have been able, from the different aspect of the filaments of each, to ascertain that the anastomoses of nerves are often merely apparent, and consist of a simple juxtaposition of two nerves without any communication of their component fasciculi, which can be traced uninterruptedly from their entrance to their emergence. The same observation applies also to some of the anastomoses between nerves of the same kind.

† In one subject, three filaments arose from the left superior cervical ganglion, and united in a small ganglionic nodule, which also received a twig from the laryngeal nerve. This ganglionic nodule gave off several pharyngeal twigs, and also the superior cardiac nerve.

quently found at the junction of the principal branches. This great cardiac plexus is chiefly formed by the middle and inferior cardiac nerves of both sides: [it also receives part of the right superficial nerves]. Lastly, all the cardiac nerves end in the third set of anastomoses, namely those upon the anterior and posterior coronary arteries around the root of the aorta.

Great as the variety may be in the course and size of the cardiac nerves up to the origin of the great vessels from the heart, there is as constant a uniformity in their arrangement around those vessels, and in their ultimate distribution to the heart.

Upon the origin of the great vessels, the cardiac nerves are arranged in three layers or sets.

The *superficial layer of nerves* is the smallest; it occupies the anterior surface of the arch of the aorta, and especially its right side; the nerves are visible without any dissection through the transparent pericardium; they all pass (*v*) to the anterior coronary artery, to the right side of the infundibulum of the right ventricle. In this superficial layer, the *superficial cardiac plexus*, may be included the ganglion of Wrisberg, when it exists, and its several branches, which in a great measure assist in forming the anterior coronary plexus.

The *middle layer of nerves* is composed of two very distinct parts, viz. of the great or *deep cardiac plexus* of Haller, which is situated between the trachea and the arch of the aorta, above the right pulmonary artery; and of a much smaller part, situated below the great cardiac plexus, from which it is derived, and between the right pulmonary artery and the arch of the aorta. In order to obtain a good view of this layer, the arch of the aorta must be cut through.

The *deep layer of nerves* is situated berween the right pulmonary artery and the bifurcation of the trachea. The trunk of the pulmonary artery must be divided in order to expose it.

The anterior and posterior coronary plexuses. The whole of the superficial cardiac plexus or superficial layer of nerves ends in the anterior coronary plexus (*v*) which surrounds the right coronary artery. The middle and posterior layers unite below the right pulmonary artery, in front of the auricles, to form a plexus which might more properly be named the great or deep cardiac plexus than the interlacement so called by Haller. From this plexus, into which the left inferior cardiac nerve enters directly, the following branches proceed; *anterior auricular branches*, which are very numerous; certain branches which pass between the aorta and the pulmonary artery to gain the right side of the infundibulum, and join the *anterior coronary plexus*, which, as we have seen already, is derived from the superficial cardiac plexus; lastly, the branches for the *posterior coronary plexus*, which surrounds the origin of the left coronary artery, and divides, like that vessel, into two secondary plexuses; one of which runs around the left auriculo-ventricular furrow, whilst the other (*v′*) enters the anterior ventricular furrow.

The nervous filaments from these plexuses soon leave the ramifications of the arteries; they proceed separately; they are all equally small, and can be seen without any dissection, like white lines, extending from the base towards the apex of the heart. They all belong to the ventricular portion of the heart; a few of them however ascend on the posterior surface of the auricles, which are much more abundantly supplied upon their anterior surface.

The cardiac nerves are not entirely distributed to the heart; several of them are lost in the coats of the aorta, some join the anterior pulmonary plexus, and some ramify in the pericardium.

The Thoracic Portion of the Sympathetic System.

In *the thorax*, the trunk of the sympathetic (*i t*, *fig.* 302.) consists on each side of a greyish cord, having as many nodules or ganglia upon it as there are vertebræ. This cord is situated, not in front of the dorsal vertebræ, but in front of the heads of the ribs, to which the ganglia for the most part corre-

spond: the two superior thoracic ganglia are the largest, and are almost always united; the succeeding ganglia are almost of equal size; the twelfth being next in size to the first and second. The ganglionic structure is observed throughout the whole extent of this part of the sympathetic, so that the cords of communication between the ganglia may be said to be merely prolongations of the ganglia. In some subjects, the ganglia cannot be distinguished from the portions of the sympathetic trunk above and below them, except by the branches which enter and converge from those points; it would therefore be a serious anatomical error to regard the portions of the trunk between the ganglia as mere filaments of communication. In some subjects, the cords between the ganglia are divided into two or three filaments. The varieties observed in the number of the thoracic ganglia are rather apparent than real: they depend, some upon fusion of the first thoracic ganglion with the inferior cervical ganglion, or of the first and second thoracic ganglia; others upon fusion of two central ganglia, or upon that, which is more common, of the last thoracic with the first lumbar ganglion; upon a transposition of the last thoracic ganglion, which is then found upon the first lumbar vertebra; and lastly, upon the two inferior thoracic ganglia being situated in the last intercostal space. Besides this, the three lowest thoracic ganglia are subject to much variety, both in situation and in shape; and the same may be said of the mode of connexion between the twelfth thoracic and the first lumbar ganglion.

The thoracic portion of the sympathetic lies beneath the pleura and the very thin fibrous layer by which that membrane is strengthened. It can be distinctly seen without any dissection in consequence of the transparency of these layers. The intercostal arteries and veins pass behind it; on the right side, the vena azygos runs along it.

The thoracic portion of the sympathetic gives off, *external branches*, or branches of communication with the dorsal nerves; and *internal branches*, which are intended for the aorta and the abdominal viscera.

The External or Spinal Branches.

There are at least two spinal branches from each ganglion, one superficial and larger, which is connected to the outer angle of the ganglion; the other deep and smaller, which is attached to its posterior surface: there is sometimes a third filament of communication. Not unfrequently these branches unite into a single trunk, before reaching the ganglion.

I regard these anastomotic branches (*e e*), between the spinal nerves and the ganglia of the sympathetic, not as branches furnished by the ganglia to the spinal nerves, nor simply as means of communication between one and the other, but rather as branches of origin of the sympathetic: this indeed is clearly demonstrated by the arrangement of these spinal branches of the sympathetic, which are always proportioned to the size of the ganglia from which they arise. In general, each ganglion communicates only with the corresponding spinal nerve; not unfrequently, however, a ganglion receives a twig from the intercostal nerve immediately below it.*

The branches of communication from the dorsal nerves to the thoracic ganglia of the sympathetic are horizontal, or rather they are inclined obliquely downwards and inwards, excepting those which ascend to the first thoracic ganglion, and those which descend to join the last thoracic ganglion. These branches are white, like the nerves of the cerebro-spinal system, and not grey like the ganglionic nerves. On examining their ultimate distribution in the sympathetic ganglia, and their connexions with the dorsal or intercostal nerves, after the parts have been macerated, first in diluted nitric acid and then in water, it is seen that these branches are evidently reflected funiculi of the

* In one subject I found a very remarkable disposition of the branches for the four inferior thoracic ganglia. Some small twigs from these four ganglia terminated in a minute gangliform structure, which gave off the branches to the spinal nerves. It will be seen that the same arrangement frequently occurs in the lumbar region.

spinal nerves; and that the nerves immediately after having given off these branches are proportionally diminished in size; that having reached the ganglia the communicating branches divide into filaments, of which some *ascend*, and may be traced upon the trunk of the sympathetic above the ganglion, and appear to be continuous with the descending filaments derived from the spinal nerve above, whilst the others *descend* to pass upon the portion of the sympathetic trunk below the ganglion; and lastly, that these white filaments run upon the surface of the sympathetic, and contrast with the grey colour of the central portion of that nerve.

The Internal, or Aortic and Splanchnic Branches.

The *internal branches of the first five or six thoracic ganglia* are exclusively intended for the aorta; some of them appear to enter the pulmonary plexus.

Some of the *internal branches of the last six thoracic ganglia* are intended for the aorta, and the remainder, which are the principal, unite to form the *splanchnic nerves* or nerves of the *abdominal viscera*. I have never seen any of them pass to the œsophagus.

The aortic branches. The *aortic branches* consist of very small filaments, of which two or three proceed from each ganglion. They accompany the intercostal arteries, around which they form small plexuses. These filaments are much longer on the right than on the left side, on account of the position of the aorta; they pass, some in front and others behind that vessel, upon which it soon becomes impossible to follow them. The aortic branch from the fourth thoracic ganglion is the only one of any considerable size; it appears to be shared between the aorta and the pulmonary plexus. A number of these aortic filaments sometimes converge towards certain small knots or ganglia, which are arranged in front or along the sides of the aorta, and give off a number of filaments.

The first thoracic ganglion sends some twigs to the cardiac plexuses; and not unfrequently the inferior cardiac nerve proceeds from this ganglion. Some filaments from the same ganglion are distributed to the lower part of the longus colli muscle.

Lobstein (*De Nervo Magno Sympathetico*, p. 19.) describes a very delicate filament from this ganglion, which perforates the anterior common vertebral ligament, and enters the substance of one of the vertebræ. A similar filament appears to me to be given off by all the cervical, thoracic, lumbar, and sacral sympathetic ganglia. The vertebræ, like the other bones, are provided with nerves, which are overlooked in a hasty examination from their excessive tenuity.

The splanchnic branches. These constitute the splanchnic nerves, which require a separate description.

The Splanchnic Nerves.

The *splanchnic nerves* are divided into the great splanchnic and the small splanchnic or renal.

The great splanchnic nerve. The great splanchnic is a white nerve, and has no resemblance to the ganglionic nerves. It is formed in the following manner: a thick branch derived from the sixth and seventh thoracic ganglia, sometimes also from the fifth and even from the fourth ganglion (see *fig.* 302.), passes downwards and inwards upon the side of the dorsal vertebræ: this branch is joined by a series of three or four smaller branches given off not only from the succeeding thoracic ganglia, but also from the communicating cords between them; these branches (*g g*) are parallel to each other, and pass obliquely downwards and inwards. The eleventh and twelfth thoracic ganglia never assist in the formation of the great splanchnic nerve.

The branches just mentioned unite on each side to constitute the *great splanchnic nerves*, which have the same relation to the thoracic ganglia that

the cardiac nerves have to the cervical ganglia: it is important to remark that the ganglionic nerves of the thoracic viscera are derived from the cervical ganglia of the sympathetic, and that the ganglionic nerves of the abdominal viscera are given off from the thoracic ganglia.

In general, the great splanchnic nerve arises by four roots; but not unfrequently it arises only by two, which then represent the four origins.

If, after having macerated the parts in diluted nitric acid, an attempt be made to determine exactly the highest point from which the great splanchnic nerve originates, it will be seen that the white filaments of which this nerve is composed are already distinct opposite the third thoracic ganglion, and, moreover, that they are merely in contact with the trunk of the sympathetic and with the ganglia, and are continuous with the communicating branches from the spinal nerves. Anatomy, therefore, most clearly proves that the splanchnic nerve is continuous with the spinal nerves.

Thus formed and completed opposite to the eleventh rib, the great splanchnic nerve passes downwards and inwards in front of the vertebral column; it becomes flattened and widened, perforates the diaphragm, the fibres of which separate to allow it to pass through, and immediately terminates in the semilunar ganglion (x). An olive-shaped ganglion is not unfrequently found upon the great splanchnic, at a short distance before the nerve passes through the diaphragm.*

The small splanchnic or *renal nerves.* I think it proper to include in the same description the *lesser splanchnic nerve* of authors and the *posterior renal* nerves of Walter, the distinction between these nerves appearing to me to be quite arbitrary. They are two and sometimes three in number. The highest is named the *small splanchnic* (h); it arises from the eleventh thoracic ganglion, and sometimes from both the tenth and the eleventh. The lowest, which is the *renal nerve* of authors, is larger than the preceding, and is derived from the twelfth thoracic ganglion (t): it often gives off a small filament to the first lumbar ganglion, and in a great number of cases this is the only means of communication between the thoracic and the lumbar ganglia of the sympathetic. In such a case the series of ganglia is said to be interrupted; but a complete interruption never exists.

The small splanchnic or renal nerves exactly resemble the separate or single origins of the great splanchnic, with which they form a continuous series. They arise in the same manner, from the two or three inferior thoracic ganglia. They pass inwards and downwards parallel to and on the outer side of the great splanchnic, perforate the crus of the diaphragm either to the outer side of or at the same point as the great nerve, and enter the renal and aortic plexuses; they are often shared between these two plexuses and the great splanchnic nerve. The highest of the small splanchnic nerves rather frequently anastomoses with the great splanchnic, or even becomes entirely blended with it.†

The Visceral Ganglia and Plexuses in the Abdomen.

As the *semi-lunar ganglia* and the *visceral plexuses in the abdomen* form the continuation of the splanchnic nerves, it is not only theoretically but practically convenient to enter upon their description now.

The central point of all these ganglia and plexuses is situated at the epi-

* Lobstein has recorded a case (p. 2) in which this unusual ganglion on the great splanchnic was of a semilunar shape, and gave off, from its convex side, seven or eight slender filaments which accompanied the aorta and were all lost in the diaphragm; he has also mentioned another case, in which three filaments arose from this ganglion, two going to the solar plexus, and the third to the mesenteric plexus.

† Among the numerous varieties which I have observed in the formation of the small splanchnic nerves, I would especially notice the following: — a twig from the eleventh thoracic ganglion, and one from the great splanchnic nerve, terminated in a small ganglion; from this ganglion were given off several filaments that were lost upon the aorta, and also a small cord which joined with a twig from the twelfth thoracic ganglion, and was distributed in the ordinary manner.

gastrium, and is formed by a ganglionic plexus, named the *solar* or *epigastric plexus.*

The Solar or Epigastric Plexus.

The *solar plexus* (opposite *x*, *fig.* 302.) is formed by an uninterrupted series of ganglia, extending from the great splanchnic nerve of the one side to its fellow of the opposite side. From this point as from a centre proceed a great number of branches, which have been compared to the rays of the sun, and hence the term *solar plexus.*

This solar plexus, which is regarded by physiologists as the centre of the nervous system of nutritive life, is deeply seated in the epigastric region, and might therefore be called the *epigastric nervous centre;* it is situated in the median line, in front of the aorta, around the cœliac axis, and above the pancreas; it is bounded on each side by the suprarenal capsules, and is of too irregular a shape to be clearly defined. The ganglia of which it is composed, the *solar ganglia*, are as irregular and variable as the plexus itself. They consist of thick and swollen cords, or ganglionic arches or circles, arranged in a network, in the meshes of which are found some lymphatic glands easily distinguishable from the nervous ganglia and cords. Anatomists, in general, describe only the two extreme ganglia of the solar plexus, in which the great splanchnic nerves terminate; these are the *semilunar ganglia* (*x*), so called from their shape, but which are subject to much variety both in form and size. Their convex border, which is turned downwards, is divided into several teeth, from each of which a pencil of nerves is given off; a great number of filaments are also given off from their concave border, which is directed upwards. These ganglia are situated close to the suprarenal capsules; they are often without any regular form, and as it were divided into fragments.

A single glance at the solar plexus will suffice to convince us of the impossibility of extirpating it, as some experimenters pretend to have done, in living animals.

The great splanchnic nerve of each side (*g*), a part of the small splanchnic nerves (*h*), and the right pneumogastric nerve (*p′*), end in the solar plexus. I have also seen the right phrenic enter this plexus.

From it, as from a centre, plexuses are given off for all the arteries arising from the fore part of the aorta, and also for the renal and spermatic arteries. The plexuses for the renal arteries and the inferior mesenteric artery are completed by the visceral nerves derived directly from the lumbar ganglia. There are two diaphragmatic plexuses, a cœliac plexus, a superior and an inferior mesenteric plexus, renal plexuses, spermatic or ovarian plexuses, and suprarenal plexuses.

All the nerves given off from the solar ganglia are grey, and very small; they are always plexiform, and are generally strong on account of the thickness of their neurilemma.

The Diaphragmatic and Suprarenal Plexuses.

The *diaphragmatic or phrenic plexuses* are small; they are given off from the upper part of the solar plexus, and reach the phrenic arteries, with which they enter the diaphragm; they at first lie beneath the peritoneum, but afterwards dip into the substance of the fleshy fibres of the muscle, and do not exactly follow the course of the vessels. In some cases I have been able to ascertain that they anastomose with the filaments of the phrenic nerve: they always run in nearly the same direction.

The diaphragmatic plexus of the right side is larger than that of the left. I have seen two ganglia, upon the right crus of the diaphragm, which formed the origin of the right diaphragmatic plexus and of some hepatic nerves.

I arrange the *plexuses of the suprarenal bodies* with the preceding, because

they have so many relations with them. They arise directly from the semilunar ganglia, by two very delicate pencils of nerves, which reach the back of the suprarenal arteries, and are lost in the substance of the suprarenal bodies. Several filaments from the diaphragmatic plexuses join them, passing in front of the arteries. The suprarenal plexuses are large in proportion to the size of the organs they supply.

The Cœliac Plexus.

The cœliac plexus is one of the principal divisions of the solar plexus, of which it is the immediate prolongation, so that it is almost impossible to distinguish one from the other: it surrounds the cœliac axis, and immediately divides like it into three plexuses, the *coronary* of the *stomach*, the *hepatic*, and the *splenic*.

The coronary plexus of the stomach. This is given off from the upper part of the solar plexus; it receives some filaments from the right pneumogastric, before that nerve joins the solar plexus; of these filaments, some ramify upon the cardia, whilst the remainder follow the coronary artery along the lesser curvature of the stomach, and anastomose with the pyloric filaments of the hepatic plexus. It follows, therefore, that the stomach is principally supplied by the pneumogastric nerve. The filaments from the coronary plexus of the stomach, as well as those of the pneumogastric nerve, after having run for some distance beneath the peritoneum, perforate the muscular coat of the stomach, and appear to be partly lost in it and partly in the mucous membrane.

The *hepatic plexus* is of very considerable size, and might be divided, after the example of Lobstein, into an *anterior* and a *posterior* plexus. The *anterior* accompanies the hepatic artery, and is formed by some twigs from the right pneumogastric, and by seven or eight large, grey, cylindrical filaments from the left semilunar ganglion, which are joined by two or three branches from the right semilunar ganglion.

The *posterior hepatic plexus* accompanies the vena portæ, and is derived almost entirely from the right semilunar ganglion; it is also composed of greyish, thick, cylindrical cords. I would especially notice one cord, which is remarkable both from its size and its course; it arises directly from the solar ganglion of the right side, passes in a horizontal and curved direction to reach the gastro-hepatic omentum, and continues horizontally between the layers of that omentum, in front of the lobulus Spigelii; it then ascends to the transverse fissure of the liver, becomes situated beneath the vena portæ, and may be traced along that vein into the interior of the liver. I have seen this great hepatic branch come directly from two ganglia situated upon the right crus of the diaphragm.

Before reaching the liver, the hepatic plexus gives off a secondary plexus of considerable size, around the right gastro-epiploic artery, the *right gastro-epiploic plexus;* it is considerably augmented by filaments which are derived immediately from the solar plexus, and perforate the pancreas.

The hepatic plexus also furnishes branches to the pylorus and the lesser curvature of the stomach, to the pancreas, to the great curvature of the stomach, and to the great omentum. The pylorus, therefore, and the great curvature of the stomach, are supplied almost exclusively by the hepatic plexus.*

The hepatic plexus likewise gives off a small *cystic plexus* which is easily seen beneath the peritoneum, surrounding the cystic artery as far as the gall bladder.

Diminished in size, from having given off a series of branches and plexuses, the hepatic plexus gains the transverse fissure of the liver, divides like the hepatic artery and vena portæ, and may be traced for some distance in the capsule of Glisson.

* The cardia and the lesser curvature of the stomach are the parts which are the most abundantly provided with nerves. The pylorus, to which we attribute such great sensibility, has incomparably fewer.

All the nerves of the liver are grey, but very strong.

The splenic and pancreatic plexuses. The splenic plexus is not so remarkable for the number as for the size of the filaments of which it is composed; it surrounds the splenic artery, furnishes some twigs to the pancreas, and it also gives off the *left gastro-epiploic plexus*, which is smaller than the right, is situated upon the great curvature of the stomach, and supplies that organ and the great omentum. The splenic plexus also gives off nervous filaments to the great cul-de-sac of the stomach, and being thus very much diminished in size reaches the hilus of the spleen, within which organ it can be easily traced in man, and still more easily in the larger animals, along the ramifications of the bloodvessels.

These nerves are grey and very strong. The numerous filaments which pass to the pancreas, and form a plexus around its arteries, constitute the pancreatic plexus, which may be regarded as a dependence of the splenic plexus.

The Superior Mesenteric Plexus.

The *superior mesenteric plexus*, which may be regarded as the lower division of the bifurcation of the epigastric plexus, is the largest of all the abdominal plexuses; it surrounds the superior mesenteric artery, forming an extremely thick plexiform sheath for it; it passes below the pancreas, enters the substance of the mesentery (*w*) with the artery, and divides, like that vessel, into a great number of secondary plexuses which are distributed to all the parts supplied by the artery, namely to the whole of the small intestine, excepting the duodenum, and to the right portion of the great intestine.

Without entering into tedious and useless details, I shall content myself with a few remarks upon the general distribution of these nerves.

The mesenteric nerves are remarkable for their length, their number, and their strength. I am certain that their neurilemmatic sheath is proportionally much thicker than that of other nerves. They are placed at variable distances from the vessels and proceed in a straight line in the substance of the mesentery towards the intestine, without giving off any filaments: at a short distance from the concave border of the intestine, they either pass directly to the bowel, or else they anastomose at an angle or in an arch; from the convexity of these anastomotic arches the filaments for the intestine are given off.

There is never more than one series of anastomotic nervous arches in the mesentery, whatever may be the number of rows of vascular arches; the single nervous arch always corresponds to the vascular arch nearest to the intestine: the filaments which proceed from it are exceedingly minute.*

The nervous filaments penetrate the intestine by its adherent border, run for some time between the serous and muscular coats, perforate the latter, to which they give some twigs, then spread out in the fibrous coat and finally terminate in the mucous membrane.

The Inferior Mesenteric Plexus.

The *inferior mesenteric plexus* (*n*) is formed by some twigs from the epigastric plexus, or rather from the superior mesenteric plexus, with which it is continuous on the front of the abdominal aorta; and secondly by some branches from the lumbar sympathetic ganglia, which, as hereafter stated, constitute the *lumbo-aortic plexus*. The meshes of the inferior mesenteric plexus are by no means so close as those of the superior mesenteric plexus.

The inferior mesenteric plexus, like the artery by which it is supported, supplies the left half of the transverse arch of the colon, the descending colon, the sigmoid flexure, and the rectum: of its filaments, those which accompany the left colic arteries are remarkable for their tenuity, their length, and for giving

* In one case I found a very remarkable anastomosis. Four filaments proceeding from four opposite points converged towards a common centre; but as they were about to cross, they diverged from one another so as to intercept a lovenge-shaped space. Two of these might be regarded as filaments of origin, and the other two as terminating filaments.

no branches in their course to the intestine. I would particularly notice the twig which accompanies the left superior colic artery. It is not uninteresting to remark that these nerves are more numerous in the iliac meso-colon which supports the sigmoid flexure than at any other point.

The inferior mesenteric plexus, thus diminished by having given off other smaller plexuses, terminates like the inferior mesenteric artery by bifurcating; the two divisions of this bifurcation are called the *hæmorrhoidal plexuses*; they surround the two divisions of the artery, viz. the superior hæmorrhoidal arteries, and terminate partly in the hypogastric plexus and partly in the rectum.

The Renal and Spermatic, or Ovarian Plexuses.

The *renal plexuses* are extremely complicated: they are formed by branches from the solar plexus, and by the two or three small splanchnic or renal nerves, and terminate almost exclusively by surrounding the renal artery.

The two *spermatic plexuses* in the male, and *ovarian plexuses* in the female, are derived principally from the renal plexuses. The *spermatic plexuses* are destined exclusively for the testicles; the *ovarian plexuses*, like the arteries of the same name, are distributed both to the ovaries and the uterus. The intimate connexions between the nerves of the kidneys and testicles in the male, and those of the kidneys, ovaries, and uterus, in the female, deserve the most particular attention of anatomists.

The Lumbar Portion of the Sympathetic System.

The *lumbar portion of the trunk of the sympathetic* (*l l*, *fig.* 302.) is situated in front of the vertebral column, along the inner border of the psoas muscle. The ganglia of this region are therefore nearer the median line than the thoracic ganglia; but the inferior lumbar ganglia not unfrequently deviate from their ordinary position, and approach the lumbar nerves as these emerge from the spinal canal: in this case they are concealed by the psoas muscle. The lumbar ganglia of the sympathetic vary much in size; some of them are so small that they would escape notice, if their greyish colour did not distinguish them from the rest of the trunk of the sympathetic.

The number of these ganglia is also variable; there are rarely more than four. Two or three ganglia are often blended into a gangliform cord; this fusion may be easily recognised by the arrangement of the communicating filaments between it and the lumbar spinal nerves.

In one subject, the twelfth thoracic ganglion on the right side was blended with the first lumbar ganglion: a small filament, corresponding in length to the thickness of two vertebræ, established a communication between this ganglion and a large gangliform cord, which represented by itself the four inferior lumbar ganglia. On the left side, the second and third lumbar ganglia were united, and the fifth was blended with the first sacral. This fusion of the lumbar ganglia almost constantly exists, and it establishes a close analogy between the lumbar portion of the sympathetic and the cervical portion, which, as we have already seen, has only three and frequently only two ganglia. It proves that the superior cervical ganglion may be regarded as representing five superior cervical ganglia and the ganglia corresponding to the two sets of cranial nerves, and that the inferior cervical ganglion may be viewed as the representative of two lower cervical ganglia, when the middle ganglion is wanting.

Moreover, the trunk of the sympathetic is not unfrequently interrupted either between the twelfth thoracic and the first lumbar ganglion, or between the last lumbar and the first sacral ganglion: this interruption is, however, more apparent than real, for, as I have already stated, the continuity between the twelfth thoracic and the first lumbar ganglion is always established by means of a small twig from the renal nerve.

The branches of the lumbar ganglia may be divided into, the branches of com-

munication between the ganglia; the external branches, and the internal branches: besides these there are some small and very delicate filaments, which enter the bodies of the vertebræ.

The Communicating Branches between the Ganglia.

These communicating branches consist of one or more white cords extending between every two ganglia; they scarcely ever have the grey appearance and ganglionic structure usually found in similar branches of communication: the communicating filament between the fourth and fifth lumbar ganglion is often wanting.

The External Branches.

These are the branches (at *d*) which communicate with the lumbar nerves. I conceive that they are furnished by the lumbar spinal nerves to the lumbar ganglia of the sympathetic. There are generally two but sometimes three for each ganglion; they arise from the anterior branches of the several lumbar nerves, as they emerge from the intervertebral foramina*; they accompany the lumbar arteries, along the grooves upon the bodies of the lumbar vertebræ, and terminate in the corresponding ganglia; they are usually directed obliquely downwards.

In general, each ganglion receives branches not only from the corresponding lumbar nerve, but also from the nerve next above it. Thus, two branches end in the second lumbar ganglion; one from the first and another from the second lumbar nerve; the third ganglion receives filaments from the second and third lumbar nerves; when one ganglion is wanting, its place is supplied by the next, which receives its own proper branches, and also those belonging to the absent ganglion. One ganglion not unfrequently communicates with three lumbar nerves.

When several ganglia are united into one, it is easy to conceive that this single ganglion must receive all the filaments corresponding to those ganglia. It is also easy to understand that these filaments must be directed more or less obliquely either upwards or downwards, and that they will correspond in length to the distance between the lumbar nerves and the single ganglion; the superior filaments being directed downwards, and the inferior filaments upwards.

A very remarkable condition of the branches of communication between the lumbar nerves and the sympathetic ganglia consists in the existence of certain ganglia or swellings upon them; and the almost indefinite anomalies observed in this particular are no less remarkable. I have found as many as three ganglionic nodules upon the same communicating branch; sometimes when the two or three communicating branches reach the side of a vertebra they unite in a ganglion from which two or three other branches are given off to the proper sympathetic ganglion.†

Moreover, these ganglia, like all the irregular ganglia, rarely present that peculiar character which is common to the regular ganglia, namely, that of forming a centre in which a certain number of filaments end, and from which others are given off.

The Internal or Aortic and Splanchnic Branches.

The *internal branches* from the lumbar ganglia are the *aortic* and the *lumbar splanchnic branches*, and form a continuous and uninterrupted series with the aortic and splanchnic branches from the thoracic ganglia; so that the internal branches from the first (*l*) and sometimes from the second lumbar ganglion join the branches from the eleventh and twelfth thoracic ganglia, to form a

* These communicating branches frequently arise in the substance of the psoas muscle from twigs derived from the lumbar plexus.

† This disposition is well seen in the beautiful plate of the sympathetic published by M. Manec.

small splanchnic nerve, which is shared between the solar and the renal plexus. Some small gangliform nodules are occasionally found upon the course of these branches, among which are some very delicate filaments, which evidently pass into the bodies of the lumbar vertebræ. All these internal branches assist in the formation of the *lumbar splanchnic*, or *pelvic visceral* nerves.

The Lumbar Splanchnic Nerves and the Visceral Plexuses in the Pelvis.

The lumbar splanchnic nerves (at *k*) pass inwards in front of the aorta, below the superior mesenteric artery, and anastomose with each other and with those of the opposite side to form a very complicated plexus, which is completed by a very considerable prolongation from the superior mesenteric plexus.

This plexus (*n*), which may be called the *lumbo-aortic* plexus, surrounds all that portion of the aorta which is included between the superior and inferior mesenteric arteries; in the intervals between the nervous filaments are found lymphatic glands, which should be carefully distinguished from some nervous ganglia which form part of the plexus.

The lumbo-aortic plexus is bifurcated below; one portion of it passes upon the inferior mesenteric artery to constitute the greater part of the inferior mesenteric plexus (below *n*); whilst the other portion descends upon the aorta, and even a little below the bifurcation of that vessel, and ends between the common iliac arteries, in front of the sacro-vertebral angle, from which it is separated by the common iliac veins. Some filaments are prolonged around the common iliac and the external and internal iliac arteries and their branches.

The aortic portion of the lumbo-aortic plexus bifurcates below into *two secondary plexiform cords*, one *right* and the other *left*, which pass downwards upon the sides of the rectum and bladder, and enter the right and left hypogastric plexuses, which are almost entirely formed by these cords.

The Hypogastric Plexuses.

The hypogastric plexuses (*m*) are among the great plexuses of the body; they supply the rectum and the bladder in both sexes, and also the prostate and testicle in the male, and the vagina, uterus, and Fallopian tubes in the female.

There are two hypogastric plexuses, one on the right, the other on the left side. They are situated upon the lateral and inferior surfaces of the rectum and bladder in the male, and of the rectum, vagina, and bladder in the female; they are distinct from each other, and are connected not by median anastomoses, which I have never been able to detect, but through the lumbo-aortic plexus, by the bifurcation and spreading out of which they may be said to be formed. The hypogastric plexuses from the enlargement and areolar disposition of their component cords, very closely resemble the solar plexus.

Each plexus is formed essentially by one of the two divisions of the lumbo-aortic plexus; it is also joined by some filaments from the inferior mesenteric plexus, by some very small twigs from the sacral ganglia, among which those derived from the third sacral ganglion are especially remarkable; and lastly by some twigs from the anterior branches of the sacral nerves (see SACRAL NERVES).

Formed by a combination of filaments from these different sources, each hypogastric plexus gives off a hæmorrhoidal, a vesical, a vaginal, a uterine, and a spermatic or ovarian plexus; all of these plexuses, like the hypogastric plexus itself, are found on each side of the body.

The *inferior hæmorrhoidal plexuses* are blended with the superior hæmorrhoidal plexuses which, as already stated, are the terminations of the inferior mesenteric plexus; they pass behind and in front of the rectum. The filaments belonging to the anterior branches of the sacral nerves may be distinguished from those belonging to the sympathetic system, by the difference in the colour of the two kinds of nerves.

The *vesical plexuses* are composed of a great number of exceedingly small filaments. They are situated upon the sides of the posterior fundus (bas-fond) of the bladder, on the outer side of the ureters, and are divided into two sets, viz. *ascending vesical* nerves, which pass upwards upon the sides of the bladder, embrace the outer and inner surfaces of the ureters, and ramify upon the anterior and posterior surfaces of the bladder; and *horizontal vesical* nerves, which run forwards upon the sides of the fundus of the bladder, externally to the large plexus of veins found in that situation, and spread out into extremely delicate filaments, of which some enter the substance of the bladder, especially at its neck, whilst the others in considerable numbers turn round the prostate gland and are distributed within it; one of the *prostatic filaments* may be traced into the membranous portion of the urethra.

The plexuses for the vesiculæ seminales, and vasa deferentia, and testicles. Some of the filaments situated on the inner side of the ureters surround the vesiculæ seminales and are lost in them; these are very small; two or three remarkably large filaments run upwards along each vas deferens; having reached the inguinal ring, they unite with the corresponding spermatic plexus, which is a production of the renal plexus, and descend to the testicle.

The branches for the prostate, vesiculæ seminales, vasa deferentia, and testicles are represented in the female by the utero-vaginal, ovarian, and tubal nerves.

The uterine nerves. Notwithstanding the figures of the sympathetic published by Walter, in which the nerves of the uterus are well represented, and notwithstanding the still more explicit description given of them by Hunter, most anatomists continue to entertain doubts regarding the existence of the uterine nerves. Lobstein, in his work on the Sympathetic, published in 1822, even denied them altogether; but Tiedemann in the same year published two beautiful figures representing the nerves of the gravid uterus.*

The uterine nerves are derived from several sources. I have already stated that the plexuses surrounding the ovarian arteries, which are productions of the renal plexuses, are distributed, like the vessels by which they are supported, both to the uterus and the ovaries.

It appears to me that the ovarian nerves and vessels have a similar arrangement, that is to say, that the uterine branches derived from the ovarian plexuses are larger than the ovarian nerves properly so called.

The tubal nerves are also derived from the ovarian plexuses.

The uterine nerves derived from the hypogastric plexuses are divided into *ascending* branches, which run upwards along the lateral borders of the uterus, pass forwards and backwards, upon the surfaces of that organ, and terminate in its substance; and into *descending* branches, which run along the sides of the vagina and terminate in it. These vaginal nerves appear to be inseparably blended with the vesical and hæmorrhoidal nerves.†

Such are the divisions of the hypogastric plexuses; analogy, rather than direct observation, has led to the admission of the existence of gluteal, ischiatic, and internal pudic plexuses; in fact of plexuses around all the branches of the internal iliac arteries.

The Sacral Portion of the Sympathetic System.

The *sacral portion of the sympathetic* (*s s*, *fig.* 302.) is formed on each side by a cord enlarged at intervals, and situated on the inner side of and along the anterior sacral foramina.

* Tabulæ Nervorum Uteri. Heidelberg, 1822, folio.

† [Dr. Lee has recently examined minutely the distribution of the nerves of the unimpregnated and gravid uterus. He has described (*Anatomy of the Nerves of the Uterus*, with plates, 1841; and Proceedings of the Royal Society, No. 49.) several large uterine plexuses; also several "large ganglia on the uterine nerves, and on those of the vagina and bladder;" and further, "two great ganglia situated on the sides of the neck of the uterus."]

It forms a continuation of the lumbar portion of the sympathetic; but sometimes there appears to be an interruption in the ganglionic chain, between the fifth lumbar ganglion and the first sacral. This interruption is merely apparent; it is never complete. The sacral trunks of the sympathetic of the right and left sides gradually approach each other as they descend, corresponding in this respect to the anterior sacral foramina.

The sacral ganglia which are rarely five, more commonly four, and sometimes three in number, are occasionally collected into a small gangliform enlargement, situated between the first and second anterior sacral foramen; the first sacral ganglion is sometimes double, and at other times it rather resembles a gangliform cord than a true ganglion.

The mode of connexion between the first sacral and the last lumbar ganglion is subject to much variety.* The manner in which the sacral portion of the sympathetic terminates is also somewhat variable. The following is the arrangement most generally admitted: a filament proceeds from the last sacral ganglion, which is usually the fourth, and forms an anastomotic arch with its fellow of the opposite side in front of the base of the coccyx. At their point of junction is often found a small ganglion (*ganglion impar*, *c*), from which certain terminal filaments are given off. Sometimes there is neither a coccygeal ganglion nor any anastomosis, properly so called, but the terminal filaments are distributed in the usual way. I have not been able to trace these filaments beyond the periosteum of the coccyx and the sacro-sciatic ligaments.

Like the other ganglia of the sympathetic the sacral ganglia present; *communicating branches* with each other; rather large *external branches* derived from the corresponding sacral nerves; *internal branches* which anastomose with those of the opposite side, in front of the sacrum, and surround the middle sacral artery. Some of these filaments I have distinctly seen entering the substance of the sacrum; and lastly, very small *anterior branches* (*y*), some of which join the hypogastric plexuses, whilst the others terminate directly upon the rectum.

General View of the Sympathetic System.

The following dissection is necessary, in order to present a correct general idea of the sympathetic system.

Take a spinal column which has been macerated in diluted nitric acid, remove the bodies of the vertebræ, leaving, if it be wished, the intervertebral substances; be very careful to preserve the branches of communication between the sympathetic and the cranial and spinal nerves.

It is then clearly seen that the two gangliated trunks of the sympathetic are connected with the cerebro-spinal axis by as many roots or small groups of roots † as there are cranial and spinal nerves; it is, moreover, no less evident that the communicating branches between the ganglionic chain and the spinal nerves do not proceed from the ganglia, but from the spinal nerves; so that it may be stated as a demonstrated anatomical fact, that the *sympathetic system has its origin in the cerebro-spinal system.* ‡

The sympathetic trunks of the right and left side generally anastomose below in front of the coccyx; it has been somewhat hastily affirmed that they

* In one case the continuation of the lumbar portion of the sympathetic deviated outwards, and joined the fifth lumbar nerve; a very small filament only formed the communication between the last lumbar ganglion and the first sacral. In another case these two filaments proceeded from the last lumbar ganglion of the right side, the inner of which joined the first sacral ganglion of the opposite side, crossing over the sacro-vertebral angle.

† It must be remembered that there are always two, and sometimes three communicating branches between the sympathetic and each of the spinal nerves.

‡ These facts in human anatomy are in perfect accordance with the observations in comparative anatomy made by Meckel and Weber, namely, that the developement of the sympathetic system is in direct ratio with that of the cerebro-spinal system; that the former is more developed in man than in any other animal, and is proportionally larger in the fœtus than in the adult.

anastomose above, either upon the pituitary body, or upon the anterior communicating artery of the brain; the true anastomoses of the two halves of the sympathetic system are in the central and median plexuses.

If, after having acquired this general idea of the trunks of the sympathetic, its neurilemma be removed by continued maceration in water, the connexions of the branches given from the spinal nerves to the ganglia, with the branches given from the ganglia to the viscera, may then be ascertained: it then becomes evident, that the greater number of the branches from the spinal nerves do not penetrate to the centre of the ganglia, but expand as it were upon their surface, and divide into two sets of filaments; of these, some are applied to the surface of a ganglion, and proceed directly to form the internal or visceral branches*; whilst the others assist in forming the cords of communication between one ganglion and another, and divide into ascending and descending filaments, of which the latter are the more numerous. They all run along the outer side of the cords of communication, and afterwards become visceral branches themselves; it is doubtful whether any filament arises in the interior of a ganglion; the continuity of them all can be traced completely through these bodies.

It follows, therefore, that it is anatomically shown that the visceral nerves given off from the sympathetic are connected or belong to a very great number of spinal nerves at once, and always to spinal nerves much higher than that portion of the sympathetic from which the visceral branches are immediately given off; and again, that the visceral or splanchnic nerves, the actual origins of which we have seen to be so complicated and so remote from their apparent origins, always run a very long course before reaching their destination. Thus, the splanchnic nerves of the thorax or the cardiac nerves are derived from the cervical ganglia; the splanchnic nerves of the abdomen are given off, for the most part, by the thoracic ganglia; and most of the splanchnic nerves of the pelvis proceed from the lumbar ganglia. Nevertheless, the proper ganglia of each splanchnic cavity complete the visceral nerves belonging to that cavity. Thus the first thoracic ganglion assists in the formation of the cardiac nerves; the superior lumbar ganglia in that of the visceral nerves of the abdomen; and the sacral ganglia in that of the pelvic nerves.

The visceral nerves sometimes pass directly to the viscera from the ganglia of the sympathetic, and sometimes indirectly, after being mingled and combined in plexuses.

There is no relation between the branches which enter and those which pass out of the several visceral plexuses, so that the branches which proceed from the ganglia and trunk of the sympathetic to those plexuses must be regarded, not as branches of formation but as branches of communication.

The visceral plexuses are also formed in a very peculiar manner, not only by interlaced nerves, but by nerves and ganglia, and these nerves themselves present a ganglionic structure altogether different from the fasciculated and plexiform structure of other nerves.

There are four great visceral plexuses; the pharyngeal plexus, the cardiac plexus, the solar plexus, and the hypogastric plexus; the largest of all these is the solar plexus, which, both in an anatomical and in a physiological point of view, deserves the title of the *abdominal brain*, which was given to it by Wrisberg. These four great plexuses may also be very properly regarded as nervous centres to which all the physiological and pathological phenomena of the nutritive system are singly or collectively referred.

These visceral plexuses differ as much from the ganglionic chain formed by the two trunks of the sympathetic as these trunks differ from the spinal cord itself: in these plexuses a sort of fusion is effected between the cerebro-spinal and the sympathetic systems, and also between the trunks of the sympathetic belonging to the two sides of the body.

* Some filaments from the spinal nerves are seen to cross at right angles over the anterior surface of the ganglia, and then to join the visceral nerves directly.

The pneumogastric assists in the formation of three of these plexuses; namely, the pharyngeal, the cardiac, and the solar plexus. In man there is a tendency to fusion of the pneumogastric with the sympathetic, and in the lower animals this fusion is still more complete; it is in those animals in which the sympathetic is the least developed that the par vagum acquires its greatest developement, and supplies the place of the former in reference to the intestinal canal.

The glosso-pharyngeal nerve also assists in the formation of the pharyngeal plexus, and the sacral nerves contribute to that of the hypogastric plexus.

The visceral plexuses differ essentially from those formed by the cerebro-spinal nerves. In the latter, the branches which emerge from the plexus are precisely the same branches that entered it, only combined in a different manner. However inextricable they may be, the plexuses of the spinal nerves are merely points in which a number of afferent branches converge and combine together. In the visceral plexuses, on the contrary, there is no relation, either in size or structure, between the afferent branches and the plexuses themselves.

The nerves derived from the sympathetic system differ also in their mode of distribution from the nerves of the cerebro-spinal system. In general, they form a plexiform sheath around the vessels, and enter with them into the substance of organs. This arrangement has induced some anatomists to believe that the sympathetic nerves belong essentially and exclusively to the vascular system, and are lost upon the coats of the arteries; others hold an opposite opinion, and deny altogether that the sympathetic nerves enter the coats of those vessels. From some researches which I have made on this subject, I believe that there are proper filaments for the coats of the vessels, but that these are very few in number, and that by far the larger number of the nervous filaments are intended for the several organs. It is not uninteresting to remark that the sympathetic nerves always accompany the arteries and never the veins; the trunk of the vena portæ forming the only exception to this rule.

A *grey colour* and a *soft* texture are not, as is generally stated, the peculiar characteristics of the nerves of the sympathetic system; the grey colour is observed only in a portion of this system; and the softness, which only very rarely accompanies the grey colour, is confined to a very minute portion of it indeed.

There are grey cords which are nothing more than prolonged ganglia, and are not nerves, properly so called; when examined they present no nervous structure, that is to say, they contain no white funiculi which can be decomposed into primitive filaments as fine as the silk fibre. Almost all the sympathetic nerves are of a white colour, which is sometimes concealed by an unusually thick neurilemma. The structure of the white nerves of the sympathetic system does not differ from that of the cerebro-spinal nerves; except that the funiculi of the former are smaller, and their arrangement is more decidedly plexiform.* Lastly, there are some mixed nerves, partly grey and partly white, which partake of the structural characters of both the grey and the white nerves.†

* See note, p. 1026.

† I am much indebted to M. C. Bonamy, my private prosector, for the zeal and ability with which he has assisted me in the numerous dissections required for the compilation of this work.

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